AdSWiM Project

for a better quality of the Adriatic Sea and a healthier habitat for all

European Regional Development Fund

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Do you SEA?

Because our Sea matters.

AdSWiM Project - *for a better quality of the Adriatic Sea and a healthier habitat for all*

ENGLISH VERSION
DECEMBER 2021

European Regional Development Fund

www.italy-croatia.eu/adswim

AdSWiM - Managed use of treated urban wastewater for the quality of the Adriatic Sea

Interreg Italy – Croatia 2014 -2020 project
ENVIRONMENTAL AND CULTURAL HERITAGE
SO 3.3 Improve the environmental quality conditions of the sea and coastal area by use of sustainable and innovative technologies and approaches

START DATE 01.01.2019
END DATE 01.01.2022
TOTAL BUDGET: € 2.035.703,13

This brochure was published by the Municipality of Udine (Italy) as responsible for the WP2 and was prepared in collaboration with all the partners of the AdSWiM Project as a part of the Interreg Italy-Croatia Programme 2014-2020.

Credits: LETTERA B sas di Patricija Muzlovic, Udine, Italy

Graphics: Marco Binelli

English editing: Richard McKenna

Edition: December, 2021

Number of copies: 1200

Printing: Easy Gadget

For more information and contacts: adswimcommunication@gmail.com

The University of Udine as the Project Lead Partner is the data processor on behalf of the data controller of all the data that regards privacy and statement (Article 4, paragraph 1, n.8 GDPR). Contact person: prof. Sabina Susmel, Via delle Scienze, 206, 33100 Udine (Italy), email sabina.susmel@uniud.it, tel.+39 0432 558602

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1

PROJECT PRESENTATION

INTRODUCTION

Twelve partners against marine water pollution to improve the quality of Adriatic Sea and coastal waters with innovative technologies in quality monitoring, treatment and management of urban wastewater.

In **36** months, **6** research institutions, **2** municipalities, **3** companies of wastewater collection, treatment and supply and 1 unit for regulation and provision of health care and education to public **have investigated and devised new treatments, new analytical devices and new chemical and microbiological parameters of the waste water.**

They've **examined the level of nutrients, pollutants and faecal bacteria** near marine discharges and depuration plants **by sampling, testing, analysing and comparing the data.**

They've **performed more than 100 events** (in person and online) to inform, educate and **disseminate data** and **transfer knowledge**. They've **created 7** types of **communication material** (leaflets, flyers, brochures, posters, rollups, short presentation and infographics videos) and **11** different promotional **items** in order to **promote awareness and encourage responsible behaviour towards the environment**, in particular water and marine habitat and ecosystems.

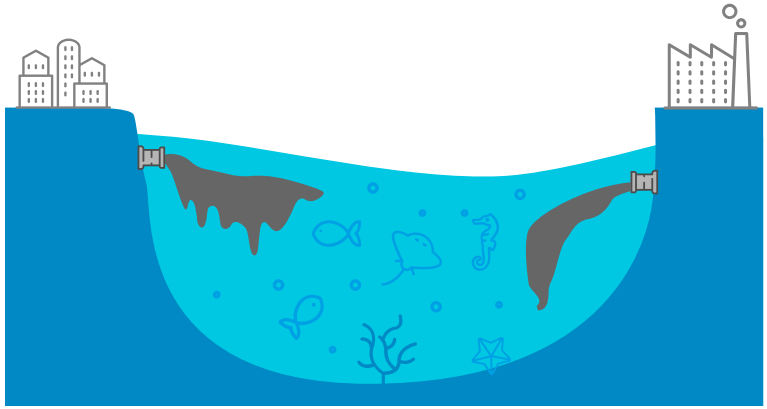
In order to increase the efficiency of the **AdSWiM research outputs**, they have **prepared new Adriatic guidelines and a common measurement model** for more efficient wastewater treatment management.

The Adriatic Sea is one.
Its care belongs to everybody.

GENERAL SITUATION

The **quality level of the Adriatic Sea** is classified from good to excellent but it **has proven to be very heterogeneous** ("Strategic Environmental Reports" 12/15/2015 - DC (2015)9285, Managing Authority Veneto Region), in particular along the coasts near to the urban areas of Italy and Croatia or close to the rivers where wastewater is discharged after depuration. It has been reported that in some areas a non-equilibrium is measured among nutrients (in particular phosphorous compared to the availability of nitrogen), and furthermore, the remineralisation of the organic matter, which could make up for any nutrient deficiency, is highly dependent on the vitality and composition of the microbial community.

For this reason, **"the abundance of species and the protection of their full reproductive capacity"** (Marine Strategy/2008/56/EC) **cannot be guaranteed over time**. An altered distribution of species in marine biological communities triggers the loss of integrity of the ecosystems and dangers to environment vitality and resilience to the diffusion of undesired species. These effects are not only negative for the environment but also potentially dangerous for the quality of bathing waters.

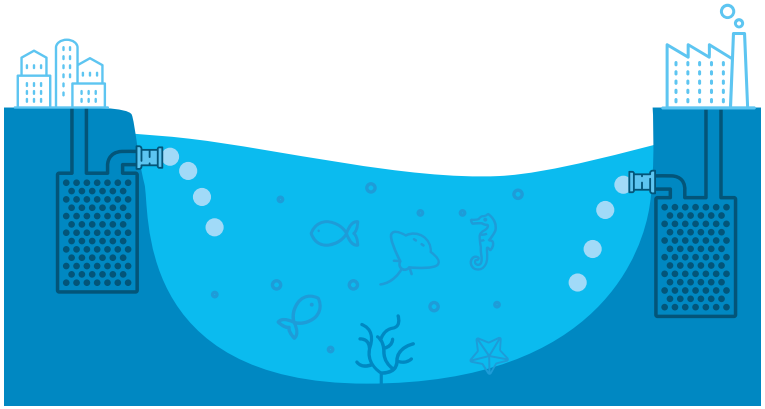


OUR MISSION

The **AdSWiM project promotes the cross-border integrated management of water resources** to restore the disturbed nutrient balance that is affecting the marine food chain in the Adriatic.

The AdSWiM project **is built around the UWW (Urban Waste Water) and DPs (Depuration Plants) or WWTPs (Waste Water Treatment Plant)**. A DP functions as a sort of a filter: it collects, screens, filters and disinfects the water so that we can have clean water for drinking, household use, agriculture and industry. The project aims to assess whether the treated UWW at the DP level, which respects established EU values, can be used as controlled point for supplying nutrients, in particular phosphorus, thus eliminating risks for both the quality of bathing water and the ecosystem's stability.

This goal is obtained through several clearly-defined activities either at a DP level or in the marine environment. Over the project's lifetime, the partners have investigated new treatments, new analytical devices and new chemical and microbiological parameters to maintain and improve the environmental quality conditions of the sea coastal areas and bathing water through the control of waste water. **An innovative and environmentally friendly wastewater treatment technology** has been developed and is proposed to gain better knowledge and control over the ecological status of the marine ecosystem in order to implement the existing regulations.



OUR GOALS

WHAT WE DISCOVERED

Do you Sea? The Adriatic Sea

The quality level of the water in the Adriatic Sea is extremely heterogeneous.

The vitality and composition of its microbial community are in danger.

The abundance of species is not guaranteed over time.

WHAT WE HAVE WORKED FOR

We can Sea! The Adriatic Sea

Sustainable and more balanced cross-border territorial development.

The improvement of the environmental conditions of the sea and the coastal areas.

The implementation of integrated wastewater managements and shared regulations.

2

PROJECT PARTNERS

UNIVERSITY OF UDINE,
Department Of Agricultural, Food, Environmental And Animal Sciences (UNIUD – Di4A)

WHO WE ARE

The University of Udine (LP - Leading Partner) is the coordinator of the project and of the partners with direct responsibility for research activities, timing and management as well as administrative activities and expenditure. The University of Udine counts more than 15,000 students and 700 researchers. The Department of Agricultural, Food, Environmental and Animal Sciences (Di4A) is organised in 9 sections. **The AdSWiM project** involves the **Chemical Section and the Biosensors and Biomaterials Division**: the researchers have heterogeneous skills in organic synthesis, electrochemistry, material characterization, microbiological and environmental / water pollution treatments to optimise easy-to-use sensor devices and to develop green materials and disinfection strategies.

UNIVERSITÀ DEGLI STUDI DI UDINE
hic sunt futura

WHAT WE DO

The University of Udine (Udine, the Friuli Venezia Region, Italy) is directly involved in:

- coordination of the partnership and keeping permanent contact with the Programme offices;
- testing of new green disinfection technologies and evaluation of their impact on the reduction of the load of pathogenic microorganisms through microbiological screen tests;
- optimization of electrochemical sensors and biosensors for rapid measurements in the field;
- analysis of the content of nutrients and microelements and pollutants for further characterization of the collected wastewater and sea waters;
- evaluation of the contribution in nutrients (the focus is on phosphorus with respect to nitrogen or carbon content) that the DP could give to the sea as a contribution to the recovery of its fertility.

The **AdSWiM team** also involves the **administrators and communications experts** who participate in the **"Do you Sea?"** awareness campaign and in particular the management of laboratories and training activities for both students and teachers with the aim of using an innovative and interactive teaching model that focuses on the end user, whether student or teacher, rather than merely communicating information.

THE INTERVIEW

Sabina Susmel,

Project manager and coordinator,
Researcher at University of Udine, Di4A

Why did you decide to undertake this project?

We live in a period in which we are finally paying attention to the quality of the environment and of the sea, also thanks to the connections between the environment and the economy and culture of our cross border areas. The situation as it stands is reassuring: the waters of the Adriatic, both on the Italian and on the Croatian side, are mainly classified as waters of excellent or good quality (95-96%). However, most regard some heavily anthropized areas or areas in the vicinity of river estuaries.
The aim of this project is to participate in maintaining the current quality characteristics of marine waters high and, at the same time, trying to improve them by working together with depuration plants in order to identify new treatment systems, new analysis and possibly new parameters or indicators for chemical-microbiological controls as an early diagnosis to identify highly persistent contaminants in water and prevent negative effects on the marine and coastal environment. Finally, we want to preserve, protect and restore the coastline of our regions.

What are the background, the economic value and the partnership?

The project was funded in 2019 in the context of the Interreg action, a programme of the European Fund for Regional Development (ERDF) and initiatives financed by the European Union to promote cross-border cooperation, in order to promote the integration of the regions of Europe and prevent national borders from hindering a balanced development of the vast European territory. The project has a value of just over two million euros and brings together 12 partners between Italians and Croats in a consortium by associating three universities, three research centres, two municipalities, three water management companies and an institution for national public health that geographically involves Italian Regions (Friuli Venezia Giulia, Marche, Abruzzo) and Croatian Counties (Istarska, Zadarska, Splitsko-Dalmatinska and Dubrovačka-Neretvanska). Due to the Covid-19 situation, the project has been extended until December 2021.

What is the most important goal?

We work to improve the treatment, control and management strategies of purified urban waste waters which, once the treatment process is finished, are discharged into the Adriatic. The aim is to maintain or improve the quality of the Adriatic Sea. We also want to obtain harmonised and shared cross-border strategy and management policies for depuration plants.

What are the challenges for the LP within the project?

At the beginning of the project we asked ourselves several questions:

- *What is the impact on the ecological state of sea water at the depuration plantpipe and along the water line of the discharge point?*
- *Can depuration plants contribute to the local composition of nutrients, local biodiversity and the balance of an aquatic ecosystem?*
- *Is the phosphorus eventually discharged in varying amounts? Does discharged phosphorus support the fertility of the Adriatic Sea?*
- *Does it make sense to try to modify the current regulation to allow the discharge of nutrients in different quantities in relation to local peculiarities?*
- *Is it possible to share cross-border management strategies also in relation to management of depuration plants?*
- *Are there any economic impacts for a depuration plant if the waste waters and (consequently the sludge) change their composition?*

Possible future developments?

If we obtain good results, the primary objective will be the transfer of technology and the application of good practices to depuration plants along the Adriatic coast, perhaps sharing and expanding the project in other European areas.

MUNICIPALITY OF UDINE (MoUD)

WHO WE ARE

The Municipality of Udine (PP1) is one of the AdSWiM project partners and it manages the administrative and expenditure procedures related to its activities in coordination with the Lead Partner. It is also responsible for the Project Work Package N°2 (WP2) – Communication activities. The Municipality counts almost 100,000 citizens and the entire territory covered by the municipal administration has an area of 57.17 km².

The AdSWiM project involves the municipal **European Projects and Participation Office** linked to the Urban Planning Department, the Environmental Office linked to the Urban Upgrading Department, and the Human Resources office linked to the Financial Services and Planning Department.

WHAT WE DO

The Municipality of Udine (Udine, the Friuli Venezia Region, Italy) is directly involved in:

- coordinating and supervising the project partners' by producing a communication strategy and coordinating related activities, managing the official project social media channels and producing the overall project visual identity materials, according to the partners' needs;
- the production of the "Document on legislative proposals for cross-border wastewater management", based on the analysis of the legislations at local, national and EU levels. In connection with this work, the Municipality of Udine contributes to developing a proposal on shared policy in WW-related issue management and quality objectives among project partners.

Together with external experts and administrators, the **AdSWiM team** is also handling the development of a set of online training modules for teachers and the creation and the promotion of an awareness-raising campaign on the issues and on sea and coastal ecosystem preservation. Linked to this, the Municipality of Udine is also involved, alongside other partners such as the University of Udine, CAFC S.p.A. the Municipality of Pescara and Metris Centre, in the organisation of labs for schools and workshops for citizens related to the wastewater treatment and sea pollution as part of the dissemination activities foreseen by the project.

THE INTERVIEW

Giulia Manzan,

Udine Council member

As an Italian Municipality you are highly active in Euro-planning. Why do you think this commitment of yours is so important?

The Municipality of Udine is currently implementing five European projects which connect Udine with other territories to tackle complex challenges that the cities are facing, such as the climate crisis and the shift to a low-carbon economy. This project involvement is therefore a great opportunity to achieve, on a strategic level, the objectives and the priorities of the EU in terms of economic, environmental, social growth and territorial integration. At the same time, it's also an opportunity to get economic resources to finance infrastructures and innovative activities at a city level. The Municipality of Udine is also committed to demonstrating to its citizens how European funds can tangibly improve their everyday life.

What is the role of the Municipality in the project and how do you manage the individual activities internally?

The Municipality of Udine is in charge of the coordination of the Work Package 2 (WP2) – Communication activities. With the help of external support from LETTERA B sas we have developed a solid communication strategy, a coordinated communication Campaign, an editorial plan, a media kit and all the communication materials for the whole partnership (flyers, leaflets, brochures, 11 promotional items), press releases, stored on two G-Drives for an internal archive. We also handle the project website and different social media management (FB profile, Twitter profile, LinkedIn group, YouTube Channel) and dissemination through media. Furthermore, our offices are also contributing to developing a shared legislative proposal for cross-border WW management, connected to the preparation of a Document on shared management policy in WW-related issues. The activities are assigned to the municipal offices involved in the project according to their areas of expertise and some external experts - legal expert Prof. Leopoldo Coen and project coordination assistant Architect Maria Cecilia Corsini - who have been contracted in order to support the municipal officers' work.

The project fell in a unique two-year period full of unforeseen events. How did you organise yourselves?

The outbreak of the Covid-19 pandemic in Europe and the Spring 2020 lockdown put several projects in standby. This situation affected all project partners, in particular the Italian ones. Once remote working had been internally set up, we progressively shifted all the activities that we evaluated as risky online and waited until the situation, from a health point of view, permitted in-person or blended events. Luckily, we managed to participate in person in some important international events, such as the European Science Open Festival - ESOF 2020 in Trieste in June 2020, we managed to organise didactic workshops for families and kids in Udine in September 2020 and we also managed to organise the Workshop for knowledge transmitters in September 2021 for experts and local and regional administrators in person and had the opportunity to meet some of our project partners face-to-face again.

What will your most important results be?

The most important result is going to be the overall goal achievement, namely, the strengthening of the cross border cooperation in order to attain an ecosystem that will be more efficient and resilient to the environmental changes driven by human activities. Secondly, thanks to the local implemented activities, we are going to contribute to raising awareness among citizens on the reuse of depurated waters based on a Strategy for sustainability in the use of natural resources. Despite the difficulties caused by Covid-19, primary schools on a local level have taken part with interest in the proposed training course for teachers on coastal ecosystems and depuration plant functioning and also in the related didactic laboratories for kids. Finally, we have had the opportunity to cooperate with all the project partners and enhance our competences by learning from others' experience.

Possible future developments and new project designs?

Interreg Europe Programme is in the process of preparing the new programme for interregional cooperation. The Municipality of Udine is keen to take part in the new Interreg projects' cycle and is striving to follow the European Green Deal and joining the global challenges to satisfy the needs of our city.

CAFC S.p.A.

WHO WE ARE

CAFC S.p.A. (PP2) is one of the AdSWiM project partners. It is a public company with its headquarters in Udine that manages the water network, sewage and WWT plants in the Province of Udine, situated in North-East of Italy. Almost 480,000 citizens use its services, which comprise more than 5,900 km of aqueduct and 4,000 km of sewer networks.

The company manages over 470 wastewater management plants (sewerage and purification), four of which with a potential greater than 100,000 equivalent inhabitants. The activities include daily verification and surveillance checks on the quality of the drinking water distributed and on the degree of efficiency of the waste water DPs. With the aim of pursuing a process of continuous improvement, the company has adopted an integrated management system certified for quality, the environment and safety in the workplace.

CAFC S.p.A. is committed in different project WPs and carries out fundamental tasks (research & development, sampling activities in the WWTPs in the sea, building up a pilot plant, sharing our experience in the management of the waste water, etc.). All activities involve WWTP in Lignano Sabbiadoro and San Giorgio di Nogaro.

WHAT WE DO

CAFC S.p.A. (Udine, the Friuli Venezia Region, Italy) is directly involved in:

- the Reefballs placement: this consists of placing under the sea 20 reef balls along about 40 meters of the undersea pipeline of Lignano Sabbiadoro WWTP to favour sea life;
- building up the bench-top photodisinfection system: CAFC Spa built the bench top to test photodisinfection technology. It is an innovative technology which permits the disinfection of wastewater without the utilization of chemicals;
- sharing information and knowledge on WWTPs with Split University (PP11): CAFC Spa was in charge of collating the data for the Italian wastewater treatment plants required for the report entitled *"Current DP management with SWOT analysis and operating mode cost-benefit"*.
- sampling and collecting of samples from the inlet of WWTPs and from the sea: CAFC Spa followed and supported the activities of sampling off-coast of Lignano Sabbiadoro and San Giorgio di Nogaro in the vicinity of two DPs.
- communications activities: CAFC Spa has been involved in various communication activities together with other partners, in particular on a local and regional level (Municipality of Udine, University of Udine and OGS).

The **AdSWiM team** involves staff from the Wastewater Division that is supported by the Environment and Safety Office as well as staff form the Communication department.

THE INTERVIEW

SALVATORE BENIGNO,

President of CAFC S.p.A.

As a company you are very open to innovation. How did you approach the themes of this project?

CAFC S.p.A. invests in and always looks for innovation. Being part of the AdSWiM project gave us the opportunity to engage with European partners with whom it would otherwise be difficult to collaborate. The AdSWiM project issues are suitable for the green politics that CAFC S.p.A. has been adopting for several years. The pilot plant, built for the AdSWiM project, represented the opportunity to apply innovative solutions directly in a real scale plant. The knowledge that CAFC S.p.A. has been accumulating over all these years permitted the development of good practices for wastewater treatment and also gives us the possibility to share and support our knowledge with other project partners.

How does the scientific transfer from the laboratory to a DP wastewater management operations take place?

Usually, the project offices develop the research and carry out the innovation activities with the support of other partners such as laboratories, research institutes or, as in this case, universities. The experimental part of the AdSWiM project, is managed completely by our company thanks to our mechanical laboratory and mechanical maintenance staff, as well as our wastewater treatment specialists Michele Mion and Nicola De Bortoli who take care of the operative questions with the help of the University of Udine. These research works are often applied to a real scale plant, thanks to the availability of almost 500 wastewater management plants managed by CAFC S.p.A..

What are your most significant activities and results?

CAFC S.p.A. commits to sharing the knowledge acquired on the management and design of wastewater treatment plants in order to support partners in project objectives. Further CAFC S.p.A. has been participating in the sea sampling campaign along the Northern Adriatic coast and near wastewater treatment plants. Regarding the collaboration with University of Udine, it is important to highlight the construction and maintenance of a pilot plant for the photodisinfection of the wastewater. The task that required the greatest effort was the organization and authorization process for the reef balls placement. Reefballs are concrete structures that were placed in summer 2021 some kilometres off the coast, at the end of the sewage pipeline of Lignano Sabbiadoro's WWT plant. These structures are now ready to host algae, the small fish nutrients, but they will also provide shelter for fish with the intent of rebuilding the trophic chain in these areas of the Adriatic. This could be called an ecologic and environmental mission which is perfectly in line with the green vision of our Company.

CAFC is a large company. How is your communication organised and how do you approach the dissemination of your activities internally and externally, in particular in relation to the education?

CAFC S.p.A. carries out continuous initiatives and activities aimed at informing and educating citizens about a correct and conscious consumption of water resources. Primary and secondary school children as well as other local organisations and communities are the main target of our awareness campaigns. Regarding AdSWiM, we have been involved in the didactic module by giving a lesson on wastewater treatment for primary school teachers, by organizing guided visits (in person and virtual) to DPs for students and experts, by organising an in-person educational workshop and lab for families and primary school kids in September 2020 where our engineer Tommaso Martin focused on the water cycle and, in particular, on the role of the wastewater treatment plant demonstration so that the children could experimented for themselves the environmental and sustainability issues. Despite the pandemic, which limited a lot of our communication activities, we found alternative solutions and even recently we have managed to take part in various educational and communication events like radio interviews, participation in conferences and university lessons. We have also participated in the project advertising campaign through Social Media and web. Finally, thanks to our head of internal communication Fiorenza Campion and the external support of LA FILMO, a video on reef ball placement has been produced and uploaded to the project's YouTube channel.

Did the period in which the project took place open up new scenarios in wastewater management? Possible future developments and new designs?

The collaborations and the links created thanks to this project gave CAFC S.p.A. the opportunity to enrich our expertise and also to focus on some aspects of the wastewater treatment, such as water disinfection and nutrient monitoring. Furthermore, AdSWiM laid the foundations for subsequent evaluations on the possibility of recovering nutrients such as phosphorus and cellulose from the wastewater process.

National Institute of Oceanography and Applied Geophysics – OGS

WHO WE ARE

The National Institute of Oceanography and Applied Geophysics – OGS (PP3) is a public oriented research Institute which operates at an international level in fields related to Earth and Marine Sciences, Oceanography, Geophysics and Seismology with the aim of contributing to the safeguarding and enhancement of environmental and natural resources, evaluating and preventing geological, environmental and climatic risks, and of promoting scientific culture and knowledge, accordingly to the EU Blue Growth strategy.

Counting on major strategic infrastructures of excellence (like its own oceanographic research vessel, the icebreaker Laura Bassi), the OGS applies its own expertise on research related to the environment and climate, biodiversity and ecosystem functionality and to the study of the seismicity, hydrodynamic and geodynamic phenomena impacting the environment and population, also for civil protection purposes.

WHAT WE DO

National Institute of Oceanography and Experimental Geophysics – OGS (Trieste, the Friuli Venezia Region, Italy) is directly involved in:

- collecting data on the quality of Adriatic waters, with special focus on the presence and abundance of faecal indicators;
- building hydrodynamic models to depict the marine areas affected by wastewater discharge;
- generating information on the bacterial community structure of treated wastewater and seawater at the discharge points through next-generation DNA sequencing techniques. The application of these tools allows the detection of emerging pathogens and non-conventional potentially pathogenic microorganisms;
- evaluating and quantifying the presence of antibiotic-resistant bacteria in seawater and treated wastewater.

The **AdSWiM team** is made up of scientists in the field of ecology, microbiology, molecular biology and environmental sciences as well as administrative staff and science communication experts.

THE INTERVIEW

Mauro Celussi,

Fixed term Researcher at the Oceanography Division

Your institution has a multidisciplinary approach. How did you set up the research and data collection of this project?

MC: The subdivision of tasks within a research team is of utmost importance. The Oceanography Division, to which most of the personnel involved belong, is characterised by multifaceted expertise and we were able to count on them. At first, thanks to the collaboration with the other project partners, we collected the available data on microbiological pollution in the project target areas. The data was then transferred to the scientists in charge of the development of hydrodynamic models aiming at the evaluation of the potential tracking of treated wastewater at their discharge sites. Based on these outcomes, the sampling stations were selected and the samples collected for microbiological and molecular analyses. In the end, a thorough analysis of results and their transfer to the stakeholders was performed.

The institute is involved in various projects with a focus on the Adriatic. Did this involvement help to provide a better framework for managing AdSWiM research data as well?

MC: Undoubtedly. Given the geographical location of OGS' laboratories, many of the studies carried out by its researchers have been focusing on the Adriatic Sea since its establishment in the 18th century. The investigations and expertise acquired over the years provided a solid baseline of knowledge of physical, chemical and biological dynamics in this marine system, being indispensable for the recognitions of natural and anthropogenic perturbations. Among the various infrastructures managed by OGS, the observation site 'C1', as part of the Long-Term Ecological Research network (LTER), constitutes a reference framework on the biological and biogeochemical variability on seasonal and inter-annual timescales by providing data for comparison purposes, also within the AdSWiM project.

How does the scientific transfer from the laboratory to the wastewater management operations take place?

MC: Our involvement in the project is mainly addressed at the study of microorganisms that 'survive' wastewater treatment processes and their discharge at sea. In a bidirectional system of information exchange, we are provided with details on the treatment technologies and the processes of their transfer to the sea and at the same time we deliver data on the characterisation of bacteria, with particular focus on potentially pathogenic microbes. This happens in the framework of the improved management of depuration pants in the light of technological improvements of treatment processes.

Viviana Fonti,

Postdoctoral Research Fellow

What have been the most surprising activities and results?

VF: The project allowed us to focus on usually understudied biological pollutants such as emerging pathogens and antibiotic-resistance genes. This has been possible through the application of cutting-edge biomolecular techniques that were essential for identifying a sort of microbial footprint, which is 'typical' for each depuration plant or strictly related to the wastewater treatment techniques in place. Consequently, these footprints can be searched for at sea to evaluate the impact of treated wastewater in the marine environment. The dramatic situation caused by the pandemic led us to unexpected activities involving the SARS-CoV-2 virus. In fact, thanks to the AdSWiM project and the molecular tools developed for it, we also search for the presence of the coronavirus in treated wastewater and seawater in selected areas in the northern Adriatic Sea. Fortunately, Covid-19 has been identified only in a very limited number of samples.

Did the period in which the project took place open up new scenarios in the research of marine waters?

Possible future developments and new designs?

VF: The AdSWiM project is high interdisciplinary. Its implementation allowed to the construction of a framework where several current hot topics can be explored. For example, it is now clear that depuration plants can represent a valid tool for surveillance, especially when pandemic pathogens are involved. The collaborations and the know-how that we have initiated and/or consolidated within the project allowed us to develop new research lines aimed at exploring innovative actions in line with the 'sentinel' role of depuration plants. Treatment sites act both as a filter and as concentrator of organisms and substances in their way from the land to the sea and are therefore very useful in understanding the variations of the nature of anthropogenic pollutants reaching the ocean. Nowadays emerging contaminants are becoming more and more popular, and among them organic molecules used in cosmetics or new antibiotic therapies are the result of the increasing need to fight microbial resistance to antibiotics.

POLYTECHNIC UNIVERSITY OF MARCHE,

Department of Life and Environmental Sciences (UNIVPM - DISVA)

WHO WE ARE

The Polytechnic University of Marche – UNIVPM is one of the AdSWiM project partners (PP4). The University, founded in 1969 in Ancona, with a mainly technical-scientific vocation, today offers more than 50 courses of study involving over 700 teachers and researchers and 17,000 students.

UNIVERSITÀ POLITECNICA DELLE MARCHE

Within the project the University is **responsible for the research Work Package (WP) N°4. that deals with innovative solutions in analytical and, microbiological controls and urban wastewater treatment.** The research work focuses on the analytical aspects for the determination of the level of nutrients and trace elements in seawater and wastewater and the evaluation of pollution in the Adriatic Sea. Our expertise in statistical analysis contribute to identifying multiple environmental stressors affecting the variability of the Adriatic Sea's ecosystems.

WHAT WE DO

The Polytechnic University of Marche – UNIVPM (Ancona, the Marche Region, Italy) is directly involved in:

- measuring the level of nutrients in the sea;
- measuring the level of trace elements in the sea;
- processing statistical analysis of the data obtained;
- assessing the quality of the coastal and marine ecosystems and proposing innovative descriptors and/or new reference models.

The **AdSWiM team** involves the Environmental Analytical Chemistry researchers of the Department of Life and Environmental Sciences (DISVA) but also the administrative staff. The researchers have been measuring the level of nutrients and trace elements in sea water to assess the pollution of the Adriatic, while the expertise in statistical analysis has helped identify multiple environmental stressors that affect the variability of those ecosystems over the course of the project's lifespan. The communication activities were carried out directly by the researchers who were highly active both with numerous scientific presentations (papers and workshops), activities for schools and citizens (guided visits and labs) and with promotional activities (radio, social media, web).

THE INTERVIEW

Anna Annibaldi,

Professor and Researcher at DISVA
of The Polytechnic University of Marche

What were the initial challenges for your institution with this project?

The initial challenge was organising as well as possible the work of all the partners involved in the activities of the Work Package 4, which represents one of the pillars of the whole project. This WP is divided into 6 tasks and also aimed to produce quite a lot of deliverables: reports, protocols and also purchasing and testing of several types of innovative equipment used during the lab work. This work package also involved many partners. The coordination of all the sampling activities in different sites and in different times of the year and in different years of the project among partners was particularly important. We needed to standardise our standards and methods and during the lockdown, due to the Covid-19 situation in both countries, many partners' laboratories were closed and the work needed to be postponed. However, thanks to the project being extended we managed to obtain all the necessary data that we needed for the final analysis.

How did you approach the research and measurement of the level of nutrients and the presence of pollutants in the Adriatic?

We set up our thematic instrumentation and checked the accuracy of the measurements with certified standard material to ensure a good analytical methodology. At the end, we compared our results with the Good Environmental status established by the European Community.

Your university has particularly distinguished itself for the commitment and involvement of young people in the "Do you Sea?" Campaign. What were the most significant actions and activities?

The Department of Life and Environmental Sciences (DISVA) is a university structure of excellence that was created in 2011 from the merger of numerous laboratories involved in a wide range of theoretical and applied research topics. Linked to the environment and the marine ecosystem, it sees the participation of over 100 scientists and technicians with highly interdisciplinary skills. Our students were actively involved in the research activities and developed posters and one young researcher also wrote a master's degree thesis on the AdSWiM project topics. We have a lot of young researchers and I must say that internal and external communication is certainly one of our strengths. We involved young researchers in the AdSWiM "Do you Sea?" campaign who became promoters of environmental awareness and educational activities. We managed to organise workshops for primary and secondary schools both in person and on line, and participated in the didactic module for teachers with lessons online. We organised guided visits for primary school children and for university students to the depuration plant in Fano in collaboration with ASET and with Jump summer camps we managed to organise two editions of educational labs for primary school kids and their families in 2020 in Fano and in 2021 in Senigallia. We managed to organise labs for citizens in 2019 and in 2021 during Sharper Night ("The Researchers' Night") with stands and creative demonstrations of the wastewater depuration process live on the streets in Ancona. We invested in promotional items that were created by the external experts of the Municipality of Udine and University of Udine and in flyers, leaflets, posters and rollups using all the communication channels available: radio, web social media and traditional ones. We are very proud of our commitment to the AdSWiM message: "The Sea is one and its care belongs to everybody".

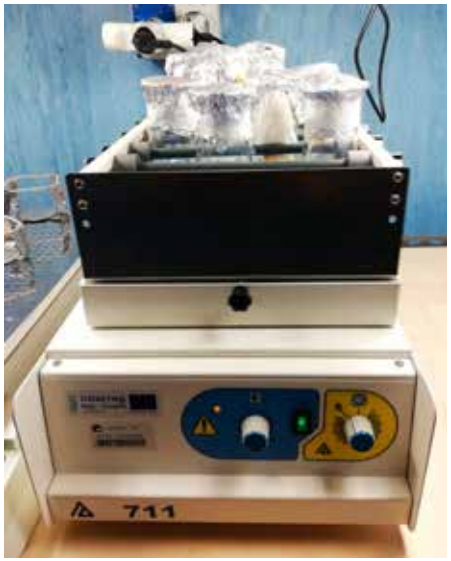
How does the scientific transfer from the laboratory to the wastewater management operations take place?

For this important transfer we needed to engage with the depuration plant managers to discuss data, results and possible implementation of "laboratory work" on a real scale plant.

What are the most important activities and results?

In my opinion, the most important result of our work is the monitoring of nutrients and heavy metals in the outflow of wastewater that was accomplished over the project's lifetime. We tested directly and can confirm the healthy status of the Adriatic Sea and also the good work of our depuration plants.

INSTITUTE OF CRYSTALLOGRAPHY – National Council of the Research (IC CNR)



WHO WE ARE

The Institute of Crystallography – National Council of Research (IC CNR) is the fifth partner of the project (PP5), with long-standing experience in microalgae biotechnology as well as design, synthesis and characterization of artificial biomimetics for biosensing application. The institute carries out studies and research activities, basic and applied, in various fields of science.

For its specifics, within its various types of know-how and multidisciplinary competences, IC has addressed different areas, such as Nanomedicine, Biosciences, Chemistry and Structural Biology, Applied Chemistry and/or Physics, Material Science, with great potential in both basic and applied research. Their research ranges from the development of crystallographic methodologies and automatic calculations of X-ray diffraction from single or powder crystals to chemistry and structural biology.

In addition, the Institute deals with physics of diffraction, studies interdisciplinary problems of structural chemistry, such as molecular modelling in the field of bio-pharmacology; it also carries out research for the design on a molecular basis, synthesis, production, crystallization and structural and functional characterization of biomolecules, in solid or liquid phase, also in interaction with ligands and / or metals, for biotechnological and / or pharmaceutical applications, whilst studying materials of technological interest such as structural nanomaterials and innovative biomaterials. Finally, the Institute develops instrumental research, including innovative sensors and biosensors, based on analysis techniques of photosynthetic proteins, suitable for multiple environmental, food and medical applications.

WHAT WE DO

The Institute of Crystallography – National Council of the Research – IC CNR (Monterotondo – Rome, Italy) is directly involved in:

- the design of algae-based bioassays for water global toxicity assessment in surface water samples;
- the development of optical biosensors for the detection of pesticides in surface water samples;
- the development of electrochemical biosensors for the detection of pathogens in surface water samples.

The **AdSWiM team** of the IC-CNR involves the Biosensor Lab entailing researchers with skills in biology, biotechnology, electrochemistry and biophysics for protein structural/functional characterization in order to develop innovative biosensors for environmental pollution monitoring. IC-CNR also includes administrators as well as a communication manager involved in laboratories and training activities for students and public events and social networks.

THE INTERVIEW

Viviana Scognamiglio,
Fixed term Researcher at IC CNR

What are the technological innovations that you decided to test with the AdSWiM project?
IC-CNR provides innovative solutions for surface water monitoring based on alarm systems encompassing the last trends in smart technologies such as electrochemical detection, nanotechnology, and material science.

How does the scientific transfer from the laboratory to the wastewater management operations take place?
The technology transfer from laboratory set-up biosensors to commercial device will be ensured by collaborations with SMEs involved in the realisation of biosensing systems for the agro-environmental sectors.

Your institute has distinguished itself for its commitment and scientific publications. Can you tell us about that?
The IC-CNR Biosensor Lab boasts very prolific publishing and dissemination of results, as evidenced by the publication of more than 20 scientific articles in peer reviewed journals with a high impact factor. My colleague Amina Antonacci and I are very satisfied with this achievement and with our contribution to the project's objectivise.

What are the most significant activities and results?
IC-CNR has studied the effect of wastewater samples on the physiological parameters of the green photosynthetic alga "Chlamydomonas reinhardtii", and thus developed an algal electrochemical biosensor for pathogen monitoring at concentrations compatible with those usually found in wastewater, encompassing all the crucial steps for the optimisation of the analytical parameters. In addition, we designed a nanomodified optosensor based on artificial biomimetics for pesticide detection meeting European regulations that establish the MRL for pesticides in surface waters (2013/39/EU).

The project funds have allowed you to make some purchases of equipment. Can you tell us which and why it is important to get this kind of research support?
IC-CNR had the possibility to purchase important instrumentations for the achievement of the project objectives and thus for the achievement of important results, also published in high impact factor journals, including a spectropolarimeter for the functional and structural characterisation of the artificial peptides then exploited for biosensor development (Deliverable D4.4.21. Protocol of synthesis of mini-proteins and/or biomimetic peptide structurally and functionally characterised). Some other small instruments have been also purchased for the accomplishment of routine experimental activities, such as a Peltier thermostat for the fluorimeter for the analysis of the artificial peptides, a pH meter, a laboratory balance, a vortex and an incubator. It is very important to be part of this kind of project, that helps research not only to have direct connections with SMEs and the world of production but also with public administrations.

MUNICIPALITY OF PESCARA (MoP)

Città di Pescara
Medaglia d'Oro al Merito Civile

WHO WE ARE

The Municipality of Pescara is the sixth project partner (PP6) and the second Italian municipal administration involved in the project. **The protection of environmental quality is one of the general strategic goals of the municipal administration of Pescara therefore the interest of the participation in the AdSWiM project represented a productive occasion to work on different topics in relation to the water depuration process.** The wastewater management that aims at the quality of the Adriatic Sea and the protection and improvement of the ecological condition of the north-eastern Adriatic area through the regulated use of purified water represents therefore a priority objective for our Municipality. **The Municipality of Pescara counts almost 120,500 citizens and the entire territory covered by the municipal administration has an area of 34.36 km².**

WHAT WE DO

The Municipality of Pescara (Pescara, the Abruzzo Region, Italy) is directly involved in:

- the collection of samples and data for the analysis of existing chemical and microbiological data and for reports on chemical-physical and microbiological parameters and surveys on emerging pathogens;
- the coordination of the investigation of cross-border DP technologies and management strategies of the feasibility studies carried out in order to highlight the strengths and weaknesses of DPs, as well as any possible difficulties arising, any innovative and positive elements and potential alternative scenarios related to our area;
- joint and shared cross-borders strategies on WWT plant management and legislative action proposals, therefore the management of the project actions that foresees the coordination of the researchers involved, in order to make the guidelines resulting from the various products of the project activity feasible and to evaluate the results with the aim of defining the value of their possible engineering.

The **AdSWiM team** involves the Office for the Protection and Enhancement of the Sea and River that is responsible for the project management and coordination of the team of the Municipality of Pescara, the Manager of the Environment and Green Area of the Municipality of Pescara and staff and head of the Office for Local Promotion and Development Policies that deal with the financial aspects and communication project activities in collaboration of external support and service.

THE INTERVIEW

Ester Zazzero,

Head of the Office for the Protection and Enhancement of the Sea and River at the Municipality of Pescara

Your municipality is involved in various projects concerning the Adriatic theme. How did you organise your work?

The Municipal Administration is involved in several projects for the Protection and Enhancement of the Sea, and I am in charge of the coordination of the activities in progress as well as of those scheduled for the period 2021-2024.

In the AdSWiM project you are collaborating with ARTA Abruzzo. How does this collaboration work?

The collaboration with ARTA Abruzzo is defined by a common agreement (pursuant to Article 15 Law 241/1990 and subsequent amendments). Based on this agreement, ARTA Abruzzo researchers and technicians have identified, as indicated in the project, sampling points at the Pretaro depuration plant of the Municipality of Francavilla al Mare and in the sea about 2.5 km off the coast, and have carried out the activities detailed in the Plan of Experimental Activities. As foreseen by the agreement, they carried out sampling and analysis with reference to specific parameters and areas of investigation for various sampling seasons.

How does the scientific transfer from the laboratory to administrative operations take place? How does the project address the issues concerning the common guidelines of the DP management?

The scientific transfer of the outcomes resulting from the observations that our offices has prepared offers an objective basis for administrative operations that aim at implementing shared and common guidelines for the management of waste water treatment plants. The innovation technologies proposed by the Research Institutions involved have been tested in CAFC S.p.A. pilot plant and ACA PESCARA DP. These results have been shared and have become part of the reports related the WWPT process innovation and test of the optimised AdSWiM solutions related also to our engagement in the Work package no. 5 (WP5) that has been carried out in collaboration with water and wastewater management company ACA PESCARA.

What are the project objectives you are most attached to?

There are three main objectives that are vitally important for our area:

- *the improvement of the ecological level of the coastal and marine ecosystem of the Adriatic Sea and the strengthening of the integrated management of water resources;*
- *the protection and improvement of the ecological condition of the sea water through the management of purified water;*
- *significant assessments of new biological parameters of water quality control as well as the optimization of analytical tools and innovative treatments for the protection of water bodies.*

The "Do you Sea?" campaign saw you engaged in various activities which include a range of targets. Can you give us some information about it?

In accordance with the public awareness campaign and strategy created and proposed by the Municipality of Udine, which is in charge of the communication work package, we immediately presented the project on our website. In collaboration with an external support for the implementation of the communication activities - Mirus s.r.l - we are promoting the activities locally among the citizens of Pescara and on a national/international level through events and participation in the workshops. We are posting news on our local Facebook page @Pescara Europa, which was created to promote the various European projects in which the Municipality is involved. Furthermore, we have also published an in-depth editorial on ***Abruzzo Economia Magazine*** *that is addressed to the institutional and economic activity of the Abruzzo region. We participated in the didactic module for teachers and after receiving signs of interest from some primary school classes, we organised educational workshops and virtual guided visits to the DP from January until June 2021 in primary schools in which children played a leading role.*

INSTITUTE OF PUBLIC HEALTH ZADAR (IPHZ)

ZAVOD ZA JAVNO ZDRAVSTVO ZADAR

WHO WE ARE

The Croatian Institute of Public Health is the seventh project partner and it is the leading public health institution in the country and Zadarska county thanks to the high level of knowledge, expertise and dedication of our experts, scientists and employees. **The Zadar Institute of Public Health has seven departments and the Department of Health Ecology and Environmental Protection is directly involved in this project, monitoring, analysing and evaluating the impact of the environment on food quality and the health status of the population.**

WHAT WE DO

The Zadar Institute of Public Health (IPHZ) (Zadar, Zadarska County, Croatia) is directly involved in:

- Field work: wastewater and sea water sampling in our geographical area;
- Chemical, physical, biological and microbiological analysis of collected water samples;
- Processing of the collected data;
- Promotion of the AdSWiM project: “Do you Sea?” campaign and awareness of seawater pollution and preservation.

The AdSWiM team includes a project manager, a communication manager and a financial manager and other experts and technicians from the Department of Environmental and Marine Protection and the administrative staff of the Department for Procurement and Implementation of EU Projects and Accounting and Finance Department with the overall support of the institution’s management.

The AdSWiM team also includes the staff who collect samples in the field for analysis and Auxiliary laboratory staff who give support in lab work. The Administrative staff handles the financial aspects, while the Accounting office deals with the procurement, the EU representatives that are responsible for data entry and Programme accountability.

THE INTERVIEW

Jadranka Šangulin,

Head of the Department for Environmental and Marine Protection / Head of the Laboratory for Marine Chemistry / Head of the Sediment Laboratory / Head of the TOC Laboratory / Head of the Gas Chromatography Laboratory

You are the only partner that does not belong to the 3 groups of project partners: educational institutions, and companies that deal with water purification and municipal administrations. How does your work relate to the project and other partners?

IPHZ analyses seawater and wastewater as required by the EU Directive, so we are closely associated with water treatment companies, municipal administrations and relevant ministries. The AdSWiM project helped strengthen cooperation with local and regional depuration plant centres. After the project, the need to improve technological solutions became clearer.

How did you involve citizens in the "Do you Sea?" campaign and what is the main message you have tried to communicate to them?

We promoted the AdSWiM project and the "Do you Sea?" campaign through local media and we organised appropriate lab and workshop activities in which families with preschool children participated. We also organised the Stirring Committee Meeting of the partnership in Zadar in person in 2019 and we organised a guided tour of our laboratories and offices for all partners and experts present during the meeting as well. We prepared a plan of the organization of labs for students to introduce high school students to the process of wastewater treatment and improving the quality of seawater at nearby beaches. Due to Covid-19 we were forced to postpone these activities and we managed to carry them out in person during 2021, when we also introduced analytical methods in a microbiological laboratory to the students. We also did some publications on local magazines and newspapers and we participate in online and social media activities. We distributed promotional items like T-shirts and other materials through traditional media channels in order to promote awareness of the message of our shared campaign.

What is the result you are proudest of?

We are very proud of connecting our work with other partners within and outside the borders of Croatia. We introduced new technologies used by project partners, using applicable knowledge and improving the work of the IPH. We gained new experiences that broadened our horizons.

The project funds have allowed you to make some purchases of equipment. Can you tell us what was purchased and why it is important to have this kind of research support?

We procured a CFA (Continuous Flow Analyser) for analysis of nutrients in seawater which allowed us faster and more accurate analysis. The CFA simultaneously analyses five parameters and reduces labour hours in the laboratory. We also purchased a data processing PC that served us well during the Covid-19 situation in allowing work from remote locations.

Possible future developments and new project designs?

We want to develop methods for microplastics in the sea and to participate in similar EU projects. Due to the procurement of several PCRs we are able to develop methods for research of SARS-CoV-2 virus in wastewater which could prevent future outbreaks.

IZVOR PLOČE Public Institution for Public Utilities Ltd. (Izvor Ploče)

WHO WE ARE

Public Institution for Public Utilities Izvor Ploče Ltd. is a water supply company operating in the area of the City of Ploče and Municipality of Gradac in Croatia.

Izvor Ploče Ltd., as AdSWiM project partner no 8 (PP8), is involved in the implementation of project activities related to conceptual innovative technical solutions for quality monitoring, treatment, and management of urban sewage system and wastewater treatment plants, as well as in continuous project management, communication and dissemination of project activities.

WHAT WE DO

Public Institution for Public Utilities Izvor Ploče Ltd. (Ploče, the Dubrovačka-Neretvanska County, Croatia) is directly involved in:

- participation in the development of a critical review and analysis of existing chemical and microbiological data;
- participation in joint investigation of cross-border depuration plant technologies, management strategies, knowledge transfer;
- participation in the development of joint and shared cross-border strategies of wastewater treatment plant management and legislative action proposals;
- development of a Feasibility Study with initiatives for the pilot site located within the PP8 operating area;
- organization of various events and workshops for the general public, experts, teachers and other identified project target groups.

In addition to researchers and engineers, the **AdSWiM team** includes the administration and communication experts who are involved in the project implementation. Specifically, these experts are involved in the project management as well as in the implementation of many communication and dissemination activities.

THE INTERVIEW

Anamarija Krilić,

water quality and safety engineer, Public Institution for Public Utilities Izvor Ploče Ltd.

Why and how did you decide to join the project and the partnership? What are your primary goals?

We decided to join the Project partnership mainly because our operating area lacks a wastewater treatment plant. The Project objectives and planned activities represented a good opportunity to help us gain better knowledge in order to improve the ecological status of the marine ecosystem through environmentally friendly technological innovations and best practices of depuration plant management. Moreover, our goal was to obtain new knowledge that would help us to improve the balance of our local aquatic ecosystem due to the recent fish reduction caused by the disturbed balance of nutrients. Finally, since tourism is one of Croatia's fastest-growing industries with a significant impact on the Adriatic Sea's resources, we wanted to gain new knowledge that would help us to improve the quality of bathing water, prevent negative effects on the marine and coastal environment, and finally protect the valuable Adriatic Sea ecosystems.

What were the primary activities you were involved in? How does your work relate to the project and other partners?

As for the project technical work packages are concerned, we are involved in the development of a Feasibility Study with actions of intervention; participation in conducting a critical review and analysis of existing chemical and microbiological data; participation in a joint investigation on cross-border depuration plant technologies, management strategies, transfer of knowledge as well as participation in the development of the joint and shared cross-border strategies of wastewater treatment plant management and legislative action proposals. Furthermore, we are involved in many project communication and dissemination activities such as the development of the project promotional materials both in Croatian and English, organization of various events for the general public, experts and teachers as well as participation in external thematic events. The project gave us a great opportunity to share knowledge, experiences, and information with other project partners, both in Croatia and Italy. Many project communication activities, like the guided study visit to the wastewater treatment plant in Split, local workshops, a didactic module for teachers, have been implemented in collaboration with the Split Water and Sewerage Company Ltd.

How did the transfer of the best practices in DP management and innovation solutions take place?

We have gained many new skills, ideas and experiences in the field of depuration plant management and innovative solutions from other project partners through joint development of project deliverables as well as through participation in the organised project meetings. The gained knowledge, especially best practices presented and discussed with other experts, will be useful when planning and building the sewage systems and waste water treatment plants at the settlements of Komin and Banja. Furthermore, we are regularly informing the various stakeholders about project activities and solutions investigated and developed over the project's lifespan.

How did you involve your target, especially experts and the local people?

In order to ensure the widest possible impact of the project results on the targeted audience, especially experts and general public, we are involved in various communication activities. In collaboration with PP9 we organised a study visit for experts to the Stupe wastewater treatment plant in Split. The main goal of the study visit was to show the entire process of wastewater treatment and the basic characteristics of a depuration plant. Furthermore, we have organised several workshops for experts: the first to present the innovative technologies for wastewater treatment and purification and the possibilities of their application at the Ploče, Split-Solin and Kaštela-Trogir conurbations; the second local workshop was organised via virtual platform and brought together several experts from the water utility companies of Vrgorac Ltd. and Metković Ltd., whereas the third was organised as a part of the in-person international SplitTech conference in Split. We have also collaborated with and organised a didactic module for primary school teachers which aimed to raise awareness and knowledge of water-related issues and to transfer knowledge to pupils.

Possible future developments and collaboration?

The AdSWiM Project has established a strong partnership on both sides of the Adriatic, which has indirectly contributed to a better understanding of many difficulties in the Izvor Ploče Ltd. operating area. The established cross-border cooperation will be nurtured in the future, in order to ensure further exchange of information, knowledge, and best practices which will definitely lead to the improvement of the Adriatic Sea environmental conditions and its valuable ecosystems.

SPLIT WATER AND SEWERAGE COMPANY LTD. (VIK Split)

WHO WE ARE

Split Water and Sewerage Company Ltd. (VIK Split) provides water supply and waste water treatment services to Split-Solin and Kaštela-Trogir conurbations and covers the area of four cities and nine municipalities in Split-Dalmatia County. VIK as project partner N°9 (PP9) is involved in the ongoing project management, communication and dissemination activities, as well as study of seawater quality in cooperation with Faculty of Civil Engineering, Architecture, and Geodesy of University of Split (PP11). VIK as project partner N°9 (PP9) is involved in the ongoing project management, communication and dissemination activities, as well as study of seawater quality in cooperation with Faculty of Civil Engineering, Architecture, and Geodesy of University of Split (PP11).

WHAT WE DO

Split Water and Sewerage Company Ltd. (VIK Split) (Split, the Splitsko-Dalmatinska County, Italy) is directly involved in:

- participation in the collection of the data related to wastewater sampling at the measuring stations of Wastewater Treatment Plants Kalinića Brig and Stupe, used for chemical and microbiological analysis;
- providing the collected data related to wastewater sampling of the central waste treatment plant carried out in the period from 2017 – 2019;
- participation in the joint research carried out at the Adriatic Sea level, organised in order to share and transfer knowledge among all PPs at the cross-border level;
- development of feasibility study with all results critically evaluated and reported SWOT analysis.

Beside its involvement in the thematic work packages, the **AdSWiM team** is also involved in the implementation of all the project's organizational and financial tasks. Specifically, PP9 is involved in the project management, as well as in the implementation of many communication and dissemination activities The team is made up of experts and technicians from the Department of Environmental Protection and operative units, EU fund specialist and external experts.

THE INTERVIEW

Boris Bulović,
EU Fund Specialist,
Sector of Investment and Development

Your company has been involved in several large-scale EU projects and investments and is noted for excellence in this sector in Croatia. How did you organise your work and optimise the harmonisation of the project overlaps?

Split Water and Sewerage Company Ltd. is currently involved in eight major EU projects, of which four are "Interreg" projects (AdSWiM, boDEREC-CE, CWC and DEEPWATER-CE). Members of the Interreg project team are experts with differing profiles, such as various administration experts and civil engineers. Each project team member has their own responsibilities, on which they actively cooperate with other team members. Finally, each of these aforementioned experts contributes directly to the implementation of activities from their professional perspective with the aim of achieving the main project goals.

As a company, you are very open to innovation. How did you approach the topics of this project?

As a company that has the objective of working on raising existing standards and improving seawater quality, the project topics were approached with special care and great respect, taking into account the fact that the AdSWiM project primarily relates to urban wastewater (UWW) and wastewater depuration plants (DP). The development of new innovative instruments through the project will lead to greater knowledge and better control of the ecological condition of coastal water near the marine discharges of wastewater treatment plants. Moreover, the innovative and environmental technologies for urban wastewater treatment will be developed, and changes to certain regulations will be encouraged in order to achieve greater standards and flexibility of protection.

How did you involve citizens and experts in the "Do you Sea?" campaign and what is the main message you have tried to communicate to them?

We consider that the clear and precise communication of the project activities to its target audience, as well as dissemination of its main results and objectives, is of crucial importance. The main message communicated through the "Do you Sea?" campaign was that the project aims to ensure the valorisation and preservation of the quality of Adriatic Sea water through application of sustainable and innovative technologies, solutions and approaches. In order to contribute to the "Do you Sea?" campaign, PP9 has prepared and printed water bills bearing the project's visual identity, logo and key information on the AdSWiM project. The invoices were sent to 100,130 service user addresses in four cities (Split, Solin, Kaštela, Trogir) and nine municipalities (Podstrana, Marina, Okrug, Seget, Klis, Muć, Dugopolje, Lećevica and Šolta). The aforementioned area, which includes the four cities and nine municipalities, represents the operational area of VIK Split and has a total estimated population of 350,000. With the collaboration of the Euroconsultants - E.C.H.R external service we also organised several workshops and events and did a lot of publications in Croatian Magazines on national level. Leaflets, gadgets, posters, roll ups were published and disseminated. We also organised a virtual guided study visit to Stupe Wastewater treatment plant with the creation of a 10' video that has been uploaded to the project's YouTube channel.

What are the results you are most satisfied with?

We are very satisfied because the conducted samplings showed that all the parameters of chemical and microbiological analysis of wastewater are acceptable. Moreover, new skills, ideas, knowledge and experiences in the field of wastewater management gained through the project will help us to ensure an even better quality of sea water.

Did the period in which the project took place open up new scenarios in wastewater management? Possible future developments and new designs?

The new knowledge and experience in wastewater management was gained through participation in the transnational meetings as well as through joint production of many project deliverables. The project will definitely encourage the development of further cross-border integrated innovative management solutions, which will ensure a balance of the sea waters' nutrients and ecosystems.

METRIS RESEARCH CENTRE, Istrian University of Applied Sciences (METRIS)

WHO WE ARE

METRIS Research Centre is an operational body entrusted with the implementation of R&D and innovative programmes in the Region of Istria. The centre is today a part of the Istrian University of Applied Sciences, dedicated to the implementation of EU and national research and development projects in relation to the improvement and legal quality control of materials to support industry and innovation in SMEs, to support the scientific sector, student programmes and promotion of science and professional education in the STEM field. METRIS's primary role lies in extremely sophisticated field analyses and the development of large, small and medium-sized trade in the national and international context through R&D services in area of advanced materials and technology for environmental and natural and cultural heritage protection, holding educational courses and implementing projects aimed at creating sustainable development for the Region.

Istarsko veleučilište
Università Istriana di scienze applicate

WHAT WE DO

METRIS Research Centre, Istrian University of Applied Sciences (Pula, The Istarska County, Croatia) is directly involved in:

- development of novel biotechnological upgrade of the costal wastewater bio treatment plants using aerobic granular biomass, in order to improve the process and energy efficiency of wastewater treatment;
- creation and testing of bacterial whole-cell biosensors for detection of heavy metal pollutants; development of a cheap and effective colorimetric bioassay for simple and economic analytical method for field applications;
- activities regarding project communication and project management, harmonization of knowledge, project areas modelling and mapping;
- technologies and strategies for managing DP guidelines definition and cross-border strategies.

The **AdSWiM team** in METRIS is made up of researchers and engineers who work alongside with external experts on the technical implementation of the project, carry out chemical and microbial contamination analysis at discharge sites and develop innovative analysing methods. However, our staff also work on other aspects of the project implementation such as project management and all-important communication with other experts, target groups and also the wider public, engaging them in the subject through the popularization of science.

THE INTERVIEW

Josipa Bilić,
Researcher and Expert Advisor at the Metris Research Centre, Istrian University of Applied Sciences (METRIS)

You are the "youngest" institution and the last partner to have joined the partnership and you cover a very important part of the project research work. Can you tell us more?

Our work is based on activities that our institute has been performing through implementation of various international projects such as analyses and biotesting on wastewater, improving the quality of wastewater that is passed through WWTPs into the sea (in our coastal area that is the case with all WWTPs) and developing operational protocols and analytical methods to be used in the process of WWT analysis. With the cooperation of other partners and external experts, our focus in the AdSWiM project is on the development of granular biomass that can improve the WWT process and development of whole-cell biosensor that can detect heavy metal pollutants on site.

Your research work of several projects in progress is related to the protection, control and monitoring of coastal pollution. Did this help you have a clearer vision and obtain better results for the AdSWiM project too?

Certainly. The various projects we are currently implementing regarding the pollution of coastal maritime line give us different perspectives and results needed for a wider comprehension of each project's outputs. So far, they have given us a better understanding of the problems in our area such as insight into wastewater quality in different WWTPs, pollutants in the coastal line, some outdated WWTP technologies, etc. and have showed us what needs to be addressed and what has to be the priority of our work.

How did you involve citizens and particularly youngsters in the "Do you Sea?" campaign and what is the main message you have tried to communicate to them?

Alongside implementation of R&D and innovative programmes, METRIS is entrusted with the popularisation of science in the Region of Istria and we cooperate with various schools in the area, participate in different science popularization events such as annual Festival of Science, and try to have as much of an "open door" policy as we can in regard to our certification. On every occasion possible, we have presented the AdSWiM project, the activities we are responsible for and the progress of the project in general to clients, colleagues, students, teachers and other target and the wider public. For us, the "Do you Sea?" campaign has certainly had greatest impact on the younger population and the message that we are trying to get through is the one we are all promoting within this project: "There's only one Adriatic Sea and it's up to all of us to look after it."

What are the results you are most satisfied with?

Well, we started with the biotests on the wastewaters collected from biological WWTP-locations selected within this project in order to produce the granular biomass and enhance the process and efficacy of the wastewater treatment process, and they have shown that there is room for improvement, especially in the segment of ammonia oxidation. This observation was important since this type of granular biomass may be principally used on wastewater treatment plants which have an increased ammonia load (in separated sewage systems) or which, for technical or technological reasons, do not comply with effluent ammonia concentration requirements. The second but no less important part of this technical project implementation was the development of whole-cell bacterial biosensor for heavy metal detection. We have developed bacterial "biosensors" that produce a colour signal in contact with heavy metal pollutants (eg. Hg). As a working microorganism, E. coli was used due to well-known genetic and transformation protocols. lacZ was used as reporter gene, since its production of beta-galactosidase in the presence of X-gal in a reaction medium produces a green-blue colour. The colour signal provides a simple reaction which does not require sophisticated instruments, which is a practical and economic method for in-the-field application. The biosensors were tested in presence of differing Hg concentrations and their efficiency has to be further validated in hyper-osmotic environment (sea water).

What impact did have the AdSWiM research work on the SMEs and spinoff activities related to your Centre's work in the sector of biotechnology and environmental protection?

The METRIS Research Centre cooperates with external experts in the field of biotechnology and environmental protection, especially Dr.sc. Šoljan and Helea Lab Ltd. who kick-started our involvement in this project. All these novel biotechnological upgrades we are talking about and working on together can be all future products for the enhancement of existing WWTP and future in-the-field analytical methods which could benefit all the subjects (SME's, research organisations, WWTP management businesses, etc.) dealing with wastewater management, biotechnology and/or environmental protection. Hopefully, that will happen once everything has been validated.

UNIVERSITY OF SPLIT, Faculty of Civil Engineering, Architecture and Geodesy (FGAG)

WHO WE ARE

The University of Split Faculty of Civil Engineering, Architecture and Geodesy (FGAG) is the eleventh partner in the AdSWiM project and lead partner for the Work package N°5 (WP5) *"Technologies and strategies for managing DPs guide lines definition and cross-borders strategies"*. The Faculty, founded in 1977, offers degree courses in Civil Engineering, Architecture, Geodesy and Geoinformatics, and professional study of Civil Engineering. Since 1993, it has offered postgraduate (doctorate) university studies as well. Courses and scientific research are carried out in 21 departments and five centres by 54 lecturers: 42 doctors of science, six masters of science, 14 assistants and 30 external associates. The Department of Water and Environmental Engineering is involved in the AdSWiM project covering a wide range of topics related to coastal water quality monitoring, hydrodynamic modelling and transport of waste water discharged by submarine diffusers, together with waste water management.

UNIVERSITY OF SPLIT,
FACULTY OF CIVIL ENGINEERING,
ARCHITECTURE AND GEODESY

WHAT WE DO

University of Split Faculty of Civil Engineering, Architecture and Geodesy (FGAG) (Split, the Splitsko-Dalmatinska County, Croatia) is directly involved in:

- development of numerical analysis of sea circulation and transport simulation of E. coli and Enterococci bacteria from two pilot sites (Zadar and Split) within the AdSWiM project;
- creating maps of bacterial transport for two pilot sites to delineate the potential locations for coastal water quality monitoring;
- conducting monitoring sessions for physical and chemical parameters at two pilot site locations within the city of Split coastal area covering two DP submarine waste water outfalls;
- investigating the cross-border DPs technologies and management, strategies of WWT plant management and legislative action proposals;
- analysing the WWT process and testing through feasibility study the possible implementation of proposed AdSWiM innovative technologies.

The **AdSWiM team** involves a permanent staff of researchers, together with new project staff hired thanks to the project who are assisting and conducting coastal water monitoring and performing data analysis with the aim of developing innovative approaches in environmental assessments of coastal water quality and transferring knowledge to local and regional stakeholders.

THE INTERVIEW

Roko Andričević,
Professor at University of Split,
Faculty of Civil Engineering, Architecture and Geodesy

What are the technological innovations that you decided to test with the AdSWiM project?

There are many aspects within the AdSWiM project that offered the possibility of leading to technological innovations and our Faculty, as engineers and researchers in water resources, have focused on developing innovative environmental assessments for coastal water quality as a result of waste water submarine outfalls.

Your institute has distinguished itself for involvement in settling and sharing DP management models, regulations and efficiency assessments. How did you approach this work in both countries?

The Interreg Italy-Croatia program in general has focused on assessing and delineating practices between countries on many different topics, one of which is wastewater management. However, the history and practice in both countries related to the coastal waste water management is somewhat different due to the differing anthropogenic impacts and particularly the baseline coastal water quality status along the coastlines of Italy and Croatia. Our approach will be to assess the current practices in both countries and through a dialog and shared experience explore the possibility of developing some cross-border strategies related to the coastal waste water submarine outfalls.

How did the scientific transfer from the university to the wastewater management operations take place?

I have been working with senior expert associate Marin Spetič, Head of Science and International Collaboration Office Petra Šimundić and postdoctoral fellow Toni Kekez throughout the project lifespan. Our Faculty has an ongoing collaboration with several municipal wastewater companies through continuous engagement of our students and providing scientific consulting for many different water-related projects. We have been working with the Split Water and Sewerage Company Ltd. (VIK Split) and the Public Institution for Public Utilities Izvor Ploče Ltd. on several deliverables in order to transfer the gained project knowledge, especially best practices presented and discussed with other experts, for the future planning and building of the sewage systems and WWT plants at the settlements of Komin and Banja.

What are the most significant activities and results?

Within the AdSWiM project our faculty participated in hydrodynamic modelling and transport simulation of bacteria released by underwater waste water outfalls, the monitoring of physical and chemical parameters in the water column at the discharging points and assessing technologies and strategies of current DP practices. Some novel environmental assessments of coastal water bodies in relation to waste water discharges could certainly be the one of the most significant project results. From the definition of guidelines and strategies for managing DPs, we had productive meetings with the Croatian Ministry of Environment and Energy in 2019 and exchanged knowledge with local, regional and national public authorities at the Water and Climate Change Conference organised by Split-Dalmatia County in 2020 (Dubrovnik Neretva county, Ministry of agriculture RH, Municipality Podstrana, City Vrlika, City Kaštela, Regional development agency of Šibenik Knin County, Hrvatske vode - Croatian National Water Management Agency , Croatian chambers of commerce Split and the one in Šibenik).

Did the period in which the project took place open up new scenarios in wastewater management? Possible future developments and new project designs?

Several new innovative technologies were investigated by the various partners but their actual implementation in wastewater management practice in both countries will depend on many factors. It is not only the financial and administrative feasibility that will be important for implementation of these technologies, but also the actual environmental coastal water quality status that needs to be achieved according to several EU directives. We must consider that the baseline water quality of coastal water bodies varies greatly between Italy and Croatia. Differing anthropogenic coastal pressures and particularly coastline development has caused different water quality statuses between the two countries and also between the northern and southern Adriatic Sea in general. Therefore, in my opinion, some possible future developments and new projects should focus on fully understanding the regional characteristics of the coastal waters and their future changes, which will happen due to new economic developments and climate impacts.

3

COMMUNICATION AND EVENTS

The Work Package 2 (WP2) "Communication Activities" was organised in four main activity groups that can be furthermore aggregated in **two principal communication engagements:** the first, that regarded **strategic organisation of tools, production and dissemination of cohesive promotional project materials** and, the second, that was related to the **synergic planned awareness education and training initiatives** that were held by the partners on both side of the Adriatic over the project's lifespan with the aim of promoting project objectives and challenges.

STRATEGIC ORGANISATION OF TOOLS, PRODUCTION AND DISSEMINATION OF COHESIVE PROMOTIONAL PROJECT MATERIALS

Campaign: "Do you Sea? Because our Sea Matters."

The first **communication strategy** was produced and approved in 2019 and it provided detailed indications and instructions about our goals, commitments, methods, tools, instruments, materials and actions in relation to the various target groups (general public, education and training organisations and institutes, local, regional and national public authorities, regional and local development agencies, SMEs and business supporting organisations). One of the threats to the efficiency of dissemination was identified in the topics of our project and outcomes that might have seemed too complex to be understood by all target groups, in particular by general public and youngsters. In response, we created a single shared visual identity for the project based around simple but strong elements. **The awareness campaign was summarised in one shared information and developed around three visuals, one pay-off and one claim: "Do you Sea? Because our Sea Matters".** The campaign was developed using three testimonials: a woman, a man, and two kids all laying upon a cactus-shaped pool toy mattress that accompanied us over all the three years of the project. Different seasons and different calls to action "hosted" different clusters of citizens: no one was excluded, as our slogan underlined: ***"There's only one Adriatic Sea and it's up to all of us to look after it".*** The Strategy was updated in 2021, due to the situation caused by Covid-19, in order to reschedule some activities and to boost new, alternative digital and blended communication tools that permitted us to pitch to our targets and the media both online and in person.

We produced **a coordinated communication and media kit in three languages** that used the Programme's official visuals and colours, **our logo and our campaign graphics,** which were used for each type of communication material produced: **office pack, event kit, press kit, visitor programme kit and lab and workshop kit, season greetings digital postcards, flyers, roll ups, partners personalised leaflets and posters, technical abstracts, and a final brochure.** Over the years we produced **11 type of promotional items** (bags, notepad, different type of pen and pencils, T-shirts, towels, soap, folding fan, Frisbee, USB pen drives for students and experts, folders, boxes for communication materials) that were personalised, if necessary, and available in different languages, and were given to the participants during the events, workshops, meeting, guided visits and labs.

Creation and management of digital tools

In order to diversify our communications, we defined and created various tools and channels. The website and all social media graphic visuals were created following the shared integrated campaign "DoyouSea?".

The **AdSWiM project website** (*www.italy-croatia.eu/AdSWiM*) was opened in 2019 and has been regular updated with news, events, multimedia materials and deliverables related to the project outcomes. All partners also presented the project on their institutional and corporate websites in the first semester of the project activities and are constantly sharing news.

Our three Facebook profile pages (@Adswimproject, @Adswim-Ic-Cnr, @Adswim_UNIVPM) were activated in 2019. The first is the institutional project profile, whereas the other two are pages relating to two Italian partners. All three profiles are synergic and are used with respect to the target diversification. We produce an average of eight monthly posts and reach about 200 followers per profile. These profiles are the main information channels for the general public, with links to newspapers, international and local groups, partners and individual employees, collaborators of the partners who were invited to support the posts and publications.

The Twitter profile @Adswimproject was opened in 2020 and has 145 followers, mainly related to the administrative and sector target, including the FVG Region Environmental Policy councillor, as well as all our partners and regional, national and international Environmental Agencies. Following the editorial plan, an average of 4 tweets per month are published and up to 10 tweets per month were produced during the lockdowns. The followers of our twitter profile are the media, other Interreg projects and scientific initiatives with similar topics.

The AdSWiM YouTube channel hosts infographic videos and six playlists created to collect materials related to partners, media presence, thematic videos, events and the link to the Interreg Italy-Croatia Programme.

However, the most powerful project social media channel is **LinkedIn.** Our **@Adswimproject** profile is linked to 620 professionals, of which 80% are technicians and operators in the sector at national level, both Italian and Croatian, 10% are media and the remaining 10% are international experts and influencers in the WWT sector. It is an important database for the training and technical workshops, as well as for the dissemination of the guidelines and protocols implemented by the project. On average, in accordance with the editorial plan we post 4/5 posts per month. We also have published four articles and one document on our LinkedIn page and we are members of four groups on wastewater management where we regularly post and participate.

The social media activities are centralised under the Municipality of Udine, and partners' staff and experts are part of the editing team. Each post tags people and all project partners. Each post published on social media produces a good percentage of views and shares, without sponsorship investments.

Two infographics videos were also created in English with Italian and Croatian subtitles. The first was launched online at the start of the project and presents the project's objectives and partners as well as a call to action for citizens to preserve the marine habitat by adopting some general good habits regarding water use and wastewater management. The second was realised at the end of the project and presented the project's results and outcomes. The infographics videos also became an educational tool used by teachers and pupils and were uploaded to the Italian digital portal of the National Institute of Documentation, Innovation and Educational Research (INDIRE) as training material for students and teachers. INDIRE has been the reference point for educational research in Italy for almost 100 years.

Agenda, Media and Press

Our awareness campaign was set up to support three categories of information and educational activities that were scheduled around the 15 International days related to the environment and nature, water and sea topics, health and scientific research with a focus on Agenda 2030, Natura 2000 sites and horizontal principles of sustainable development. An editorial plan was created and all our media and press work supported the planned activities and the project outcomes. Almost 135 articles were published in local, regional and national newspapers, magazines (Italian 50%, Croatian 38%, others 12%), four radio interviews and two TV editorials were recorded, reaching almost 7 million users/readers. More than 20 bilingual official press releases were produced and 12 editorial articles were written. 15 scientific articles were published. Furthermore, in relation to our project awareness Campaign, in May 2020 VIK Split printed the campaign's main image on the back of water bills together with some recommendations on how to keep the environment clean. These bills were delivered to 100,130 consumer addresses in four cities (Split, Solin, Kaštela, Trogir) and nine municipalities (Podstrana, Marina, Okrug, Seget, Klis, Mućo, Dugopolje, Lećevica and Šolta) that included almost 350,000 inhabitants.

SYNERGIC PLANNED AWARENESS EDUCATION AND TRAINING INITIATIVES

National, International events and Workshops

We organised, hosted and/or participated in 110 events in person, online and in blended editions. Each partner hosted at least one workshop and participated in at least in two major events.

Most of the events were technical workshops or conventions or scientific meetings (such as **WaterSafetyPlan Convention, BioMA, Biocampa, DESIR, XVII IHSS Symposium Torino, AIOL Congress, PhD Ocean Hackathon**) or scientific or technical conferences and fairs (**ABC Urbino, Festival dell'Acqua, Marano Lagunare workshop on Quality of waters and fertility of Sea, Water and Climate Conference Split, Crofish, Sealogy, Remtech Europe, ESOF TRIESTE, Giornata Bioanalitica Conference, The World Congress of Biosensors**). Some of the events involved the general public and students as well (such as **Researcher's Night in Rome and Ancona and Festival Znanosti in Pula, Zadar and Split**) held in person and online, due to Covid-19 restrictions. Several joint meetings were organised with other Interreg Italy–Croatia projects (**Watercare, Ecomap, Asteris**) or other EU projects on overlapping issues (**EUSAIR Forum, BoDEREC-CE, City Water Circles – CWC**) in order to strengthen cooperation between public administrations, scientific and research institutions and water managers. Several workshops for schools and universities were organised in different project areas and also online (such as **Ada Lovelace Day and Chemist table Day in Rome, Nautici in Blu in Trieste, PLS workshop in Iesi, Smart open Days and Orienta Days of UNIVPM, Environmental Course and Sustainability Course of UNIUD**). Various social media campaigns were organised that also included participation in online events and dissemination of international campaigns (**EU Water Day congress, EU Health Day Congress, International Social Day and a video realisation for Interreg Italy–Croatia Programme, SLAM Interreg competition, Comunicare Interreg with the Italian Agency for Territorial Cohesion, EU Research Day and Congress, Girls' Day and Education day, Mediterranean Day** with the realisation of one shared poster with photos of sea colours from different AdSWiM locations, etc.).

The **First Kickoff conference** was organised in April 2019 in person in Udine (Italy), whereas, due to Covid-19, the **Final conference** was held online in December 2021 in order to reach as many stakeholders as possible.

Guided study visits and open doors

12 in-person guided study visits and open door events for schools, citizens and experts were organised together with **3 virtual ones**. A **12' video** was also realised that presents a **detailed guided visit to a DP in Stupe Split** and was uploaded to AdSWiMs YouTube channel. A **visitor programme kit** was created consisting of 4 personalised DP visit leaflets and promotional items in collaboration with the water and sewage management partners and territorial companies involved (CAFC S.p.A, ACA PESCARA, ASET FANO, VIK Split and IZVOR PLOČE). In addition to this, a **short video of reefballs placement** was created.

Didactic Modules and Laboratories

In 2020 a **didactic module** was created based on the "take action" concept and addressed to pupils and teachers of primary schools focusing on the promotion of water protection issues and wastewater management education. The didactic module involved several Italian and Croatian partners and 51 teachers and almost 600 primary school pupils from all regions (the Friuli Venezia Giulia Region, The Marche and the Abruzzo Region, the Istrian County, the Dubrovnik-Neretva County and Split-Dalmatia county). The didactic module, based around 8 different lessons, obtained patronage from the University of Udine and PREESOF 2020. The lessons were to take place in person and on site, but due to the lockdown we transferred the entire training course online from January until June 2021. The final meeting was held online on June 8th, International Oceans Day, during which some teachers presented the work carried out in classes on the project topics by using **"an infographic"** as a teaching method with pupils. Video lessons were recorded and AdSWiM certificates of participation in two graphic formats were produced and distributed to teachers, pupils and classes for their participation. The Italian teachers could also request S.O.F.I.A accreditation as the module was approved by the Italian Ministry of Education. A **lab and workshop kit for kids** was created consisting of 7 personalised lab leaflets and gadgets in collaboration with institutions (UNIUD, UNIVPM, METRIS, IHZ), water companies (VIK and IZVOR) and municipalities (MoUD, MoP). **12 laboratories for kids** were held in presence in museums, local schools, and summer camps on territory in Fano, Senigallia, Udine, Pula, Zadar and online from Pescara, Ancona). Also **four kids' corners were created in digital format** and promoted through project social media and website.

> 7 million people reached
4 social media channels and 1 website
110 events organised
11 promotional items

> 130 articles about our work
15 scientific publications
600 pupils and 80 teachers involved
7 types of promotional formats

In shortlist of the top 10 best European projects for the SLAM Interreg competition in the 2020 Youth section. Selected by the PROESOF 2020 scientific committee for the promotion, development of the didactic module and training with schools. Good practice of the Italy-Croatia Program, communication and dissemination with the public, presented at 5th EUSAIR Forum Belgrade in January 2021.

Good practice and the only project of the Italy Croatia 2014-2020 Program presented at "Comunicare Interreg", an event organised by the Italian Agency for Territorial Cohesion and the Puglia Region, in line with "Europe closer to citizens" and for activities that protect and improve the urban environment and educate and inform citizens, in order to achieve local and global sustainability.

4

PROJECT RESULTS

The Work Package 3 (WP3) "Harmonization of knowledge, project area modelling and mapping, activities planning" was created as a set of activities that were necessary for developing the project's implementation.

Data Collection

First of all, a collection of existing data was carried out, pertaining to both Croatian and Italian waters. Data generated in previous research and monitoring programme was used to create **a common and shared baseline knowledge** in order to define the current cross-border status of bathing water quality and ecosystem features in general, in relation to nutrients, trace metals and fecal indicator bacteria (*Escherichia coli* and Enterococci). These datasets were critically analysed, with the aim of understanding the pollutants' pathways in relation to depuration plants outfalls at sea.

Mapping and modelling and fluid dynamic simulations

To achieve this, **hydrodynamic models** were created both for the northern Adriatic and for the Dalmatian coasts. The generation of these models was intended to be used in the **construction of a sea monitoring plan** aimed at implementing 'classical' laboratory procedures with the innovative analytical methods/devices which it was planned would be developed in Work Package 4 (WP4).

Sampling

However, due to the extreme variability of marine currents in the study areas, the choice was taken to analyse seawater samples collected only in the proximity of the outfall of DP pipelines. Finally, all the partners agreed on **the sampling strategy** and on the activity to carry out both on seawater and treated wastewater samples. These included the analysis of macronutrients, metals, fecal indicator bacteria (classical approach), emerging pathogens (both enumeration of bacteria of the genus Pseudomonas and DNA-based analyses of the whole bacterial community to highlight unconventional, potentially pathogenic microbes) and antibiotic-resistant bacteria. Water samples were also collected to develop novel analytical procedures in the field of chemical measurements, disinfection and ecotoxicology.

6 depuration plants involved
2 modelling approaches tested
6 databases questioned
1188 microbiological data analysed for background seawater quality
> 99% of samples showed good or excellent quality of seawater

The Work Package 4 (WP4) "Innovative solutions in analytical, microbiological control and to treat urban waste waters (UWW)" was organised into five specific and interconnected activities, essential to achieving results in improving the depuration process and its control.

Monitoring of physical and chemical parameters and mapping of bacteria

The aim of this WP was to implement technological and control solutions to obtain tools, and thus offer services, for the assessment and promotion of environmental quality and to ensure that the en-

vironment is protected from the effects of wastewater discharge. The challenge of this articulate WP was to develop new analytical methods and devices and compare them with the classic instrumental procedures, for application in three crucial fields for wastewater treatment:

- Disinfection process
- Chemical control
- Microbiological control

DISINFECTION PROCESS

Photodisinfection and granular biomass were the technologies tested to reduce the microbial load coming from the wastewater. As regards the photodisinfection process, a protocol was assessed to prepare a photoactive material using PVC as a binder doped with a new synthesised photoactive molecule. This PVC based photoactive layer was tested in standard conditions to confirm its efficacy as an antibacterial treatment. A benchtop pilot plant was constructed but the preliminary results showed that this technology was not mature enough to increase its TRL or in other terms to pass from lab scale to pilot plant scale. Aerobic granular biomass was also tested with this same aim. The results at lab level were encouraging and granular biomass was successfully applied on the aerobic step of wastewater treatment plants (WWTP) both in Italy and in Croatia, improving the nitrification process and energy efficiency of the treatment.

CHEMICAL CONTROL

As regards chemical control, waters from six depuration plants and respective outflow in seawater were checked, both in Italian and in Croatian sites. The determination of nutrients and trace elements was performed in all samples **by classic and new analytical methods.** The concentration of nutrients, in general both in Italy and in Croatia, were from two to three orders of magnitude higher in wastewater samples compared to seawater samples, which indicates the relatively low impact of nutrient inputs from the WWTP on the state of the marine environment. **Analysis showed that dissolved inorganic phosphorus is a limiting nutrient at the investigated oligotrophic sites.** Therefore, **the control of orthophosphate inflow through wastewater and regular monitoring of the marine environment in the vicinity of the WWTP is crucial for maintaining a very good environmental status.**

To improve this important aspect for monitoring activities **a sensor was developed for orthophosphate determination *in situ:*** from the standard aqueous solution used during the optimization, treated wastewater and seawater were then tested using a developed plastic conductive electrode based on an embedded, purposely prepared molybdenum derivative. The limit of detection gained was of about 1 to 5 nM so from 10 to 15 times lower than the limit offered by the conventional instrumental approaches. **The low cost fabrication of the electrodes as well the portability of the technology opens up the possibility of using this method to monitor phosphate levels in oligotrophic seawater samples, achieving one of the objectives of the AdSWiM project.**

Passing to the potential trace elements (PTEs) there were low levels of mercury, arsenic and cadmium both in Italy and in Croatia, below the legal limits fixed both for WWTPs and for seawater (Environmental Quality Standard EQS): **we can conclude that as regards PTEs, DP outflows did not imply pollution effects for bathing waters in the Adriatic Sea.**

A new device was also built: for metals **a bacterial biosensor based on plasmid vector was developed and tested for mercury detection in contaminated waters,** providing a novel analytical procedure to measure this contaminant.

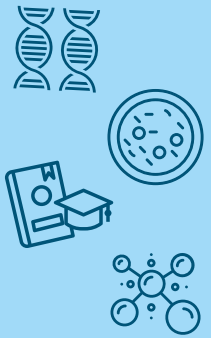
MICROBIOLOGICAL CONTROL

Several complex activities involving **microbiological control** were carried out. First of all, **the characterization of the prokaryotic communities by next generation sequencing (NGS) and the surveying of antimicrobial resistance genes** were executed. Treated sewage samples collected from wastewater treatment plants (WWTP) showed a clear differentiation from those obtained at sea and close to plant discharging points. Differences were considerable even at low taxonomic resolution (i.e., phylum level), with WWTP samples characterised by high relative abundances of Firmicutes, in contrast with its very low relevance in the seawater samples. Moreover, faeces- and sewage-associated bacterial taxa were found in larger proportions in the Croatian treated sewage (i.e., undergoing primary treatment only) compared to the Italian ones.

Experimental activity plan

Concerning the **global biotoxicity analysis of WWT, an electrochemical biosensor was developed for pathogen detection based on microalgae whole cells immobilised on carbon black nanomodified screen-printed electrodes and associated to a dual electro-optical transduction prototype ad hoc designed for algal photosynthetic process.** *Escherichia coli* was exploited as case study pathogen to assess the algae capability to sense their presence in WWT. Indeed, **aerobic bacteria can promote algal growth and thus oxygen evolution by reducing the photosynthetic oxygen tension within the microenvironment of the algal cells.** *E. coli* was analysed in a concentration range from 100 to 2000 CFU / 100 mL, and an increase of the current signals and thus of the oxygen evolution of 10 % was registered in the presence of 1000 CFU / 100 mL and 25 % in the presence of 2000 CFU / 100 mL of pathogen concentration. A detection limit of 92 CFU/mL was achieved (LOD = 3×sd/slope). Moreover, **an optical biosensor based on D1 bioinspired peptidomimetics functionalised with quantum dot nanoparticles was designed for the detection of atrazine,** a case study herbicide widely exploited in agriculture and often found in WWT. This biosensor showed excellent sensitivity toward the atrazine target, with detection limits in the µg/L concentration range, meeting the requirements of E.U. legislation.

106 DNA sample
44706 total bacteria 'species' (ASVs)
2100 analyses for nutrients and trace elements
2000 electrodes prepared and tested to optimise proper formulation and detection
5 important analytical instrumentations
15 research papers published
1 PhD thesis
3 master degree thesis
2 private companies for biosensor development involved



The Work Package 5 (WP5) "Technologies and strategies for managing DP guidelines definition and cross border strategies" was structured in line with the general Interreg Italy-Croatia program focus on assessing and delineating practices between the two countries. However, the history and practice related to the coastal wastewater management of both countries varies due to the different anthropogenic impacts and particularly due to the baseline coastal water quality status along the coastline of Italy and Croatia.

Investigation of cross-border DP technologies and WWT management strategies

For this reason, we approached our working plan with the investigation and the assessment of the current practices in wastewater management in both countries and through a dialogue and shared experience between the partners, in particular the water and sewage and DP managers, involved in the project. During the first year, the activities completed included the **evaluation of existing wastewater treatment technological processes of the DPs in Italy and Croatia, the identification of their strengths and weaknesses and an analysis of costs and benefits of current operating modes.** The presence of some "hot spots" with the highest risks of coastal pollution were highlighted. The assessment confirmed that **each WWT plant involved has different characteristics due to its local context and to the different types and size of the affected area and policies used for the reuse of purified waters.** Thanks to the hydrodynamic models that were created, both for the northern Adriatic and for the Dalmatian coasts in Work Package 3 (WP3), and thanks to the monitoring plan and sampling completed by the research institutions, the partners were able to begin the implementation of the laboratory procedures and the testing with innovative analytical methods/devices in accordance with the activities in Work Package 4 (WP4) and at the same time, the activities of the WWT process innovation, focusing on various tests and pilot plants and the feasibility study of the efficacy of the innovation being tested were ready to start.

WWT process innovation and testing of the optimised AdSWiM solutions

The work proceeded during the second year with the Development of strategies for improving DP processes by taking into account available technologies and particular characteristics of pilot areas as well as administrative and technological demands. Furthermore, we proceeded with the **feasibility assessment taking into account economic and technological aspects, with the aim of defining actions for implementation of one or more novel technologies** (photodisinfection, granular biomass, biosensors) within selected depuration plants including an analysis of sludge composition. Responsible partners selected the pilot sites on the basis of existing DP technologies and capacity for sludge removal and treatment. A bench top to test the photodisinfection technology which permits the disinfection of the wastewater without the utilization of chemicals was built at CAFC S.p.A. Implementation and testing of submerged structures for mitigation of wastewater effect was completed in spring of 2021 with the placement of 20 reefballs along about 40 meters of the undersea pipeline of Lignano Sabbiadoro WWTP in Italy. Already in Autumn an underwater video was shot that shows the benefits and initial repopulation of marine life inside the reefballs. On the Croatian side, a newly designed wastewater treatment facility in the City of Split was selected to test the possibility of implementation of innovative technologies. The partners on both sides of the Adriatic were regularly involved in sampling campaigns and collecting of samples from the inlet of WWTPs and from the sea and they followed and supported the activities of sampling off-coast and in the vicinity of DPs. Six DPs were involved in the analysis of the conducted samplings of the parameters of chemical and microbiological analysis of wastewater.

One of the project objectives was to verify if the treated urban wastewater could become a controlled source of nutrients for oligotrophic marine environments. Today, after all the analyses that were conducted in the WP4, we know that to obtain an answer to this question we must increase the knowledge and characterization of the receiving marine area from a chemical-physical and microbiological point of view, carry out detailed analyses of the treated wastewater and estimate its contribution in nutrients in comparison to what is conferred by the surrounding hinterland. Rapid measurement systems for chemical and microbiological control can help and provide the answer to this question.

Legislative proposal for cross-border WWT management and knowledge transmitter training

Legal experts Prof. Leopoldo Coen (the Faculty of Law, University of Udine) and Prof. Silvija Petrić (the Faculty of Law, University of Split) drafted a comparative analysis of the Italian and Croatian legislation on wastewater treatment. Their expertise is Environmental Law, Urban planning and procurement law, in the case of Pro. Coen, and Civil Law, European private Law and Consumer Protection Law for the in the case of Prof. Petrić. Their combined knowledge was perfectly suited to exploring the possibility of developing a proposal for a general cross-border strategies related to the coastal waste water submarine outfalls and WW Management. The work began from the analysis of the legal framework of reference, which includes European, state and regional legislation, and then we moved on to illustrating the prerogatives and areas of intervention of the various institutional subjects present in this sector. The discipline of discharges and the organization of the water and purification system were subsequently examined, also in light of the infringement procedures instituted by the European Union in cases of non-compliance with the directives. Finally, the Croatian regulatory system was compared with the Italian one, highlighting similarities and differences.

The result of this work is a report on risk and weakness of the normative and programmatic framework and the identification of common elements that can allow the partners to formulate jointly, alongside the involvement of the target groups, shared cross-border goals in WW-related issue management with a short- to medium-term vision.

A training module for "knowledge transmitters" of the project results was developed and presented during a workshop in September 2021 in Udine (Italy) to 36 participants of local administrations, agencies for Environment and NGOs present during the event. The project results were also presented at a Croatian National roundtable in Split in October 2021 that gathered 22 key stakeholders who are co-creating the legal and policy framework of water management within CWC - City Water Circles project (co-financed through the Transnational cooperation program INTERREG Central Europe 2014-2020).

1 survey on cross border 6 DPs
8 reports about WW technologies, innovation, management and cross border policy and strategy
1 legislative action proposal for cross-border WW management
1 training module for knowledge transmitters

5

ANNEXES

AdSWiM Research publications:

1. Bartolucci, C., Antonacci, A., Arduini, F., Moscone, D., Fraceto, L., Campos, E., ... & Santander, J. M. P. (2020). *Green nanomaterials fostering agrifood sustainability.* TrAC Trends in Analytical Chemistry, 115840.
2. Antonacci, A., & Scognamiglio, V. (2019). *Biotechnological Advances in the Design of Algae-Based Biosensors. Trends in biotechnology.*
3. Scognamiglio, V., & Arduini, F. (2019). *The technology tree in the design of glucose biosensors.* TrAC Trends in Analytical Chemistry, 115642.
4. Castrovilli, M. C., Bolognesi, P., Chiarinelli, J., Avaldi, L., Calandra, P., Antonacci, A., & Scognamiglio, V. (2019). *The convergence of forefront technologies in the design of laccase-based biosensors-an update.* TrAC Trends in Analytical Chemistry.
5. Antonacci, A., & Scognamiglio, V. (2019). *Photosynthesis-based hybrid nanostructures: electrochemical sensors and photovoltaic cells as case studies.* TrAC Trends in Analytical Chemistry.
6. Antonacci, A., & Scognamiglio, V. (2020). *Emerging technologies in the design of peptide nucleic acids (PNAs) based biosensors*, TrAC Trends in Analytical Chemistry.
7. Antonacci, A., Locelso, F., Barone, G., Calandra, P., Gruneberg, J., Moccia, M., Gatto, E., Giardi, M.T., Scognamiglio, V. (2020), *Novel atrazine-binding biomimetics inspired to the D1 protein from the photosystem II of Chlamydomonas reinhardtii*, International Journal of Biological Macromolecules, Volume 163, 15 November 2020, Pages 817-823
8. Truzzi, C., Iluminati, S., Girolametti, F., Figueredo, F., Susmel.S, Annibaldi, A. (2020), *Electrochemical phosphate detection in oligotrophic seawater with a stand-alone plastic electrode*, Eighth International Symposium "Monitoring of Mediterranean Coastal Areas. Problems and Measurement Techniques", nr. 27045846, Fupress.
9. Antonacci, A., Attaallah, R., Arduini, F., Amine, A., Giardi, MT., Scognamiglio, V. (2021). *Dual electro-optical biosensor based on Chlamydomonas reinhardtii immobilised on paper-based nanomodified screen-printed electrodes for herbicide monitoring*, Journal of Nanobiotechnology volume 19. Article number: 145
10. Sabina Susmel, S., Figueredo, Arduini, F., Antonacci, A., Scognamiglio, V., (2021), *Innovative (bio)sensors in the frame of interreg Italy-Croatia ADSWIM project "managed use of treated urban wastewater for the quality of the adriatic sea"*, Abstract book "New technologies for sensors and biosensors @ CNR- Research Area of Rome 1, project «Depositions for ElectroSpray Ionization and biosensoRi-DESIR».
11. Thandu, M., Rossi, G., Goi. D, Guerriero, P., Poletti, D., Strazzolini, P., Comuzzi, C., (2021). *Synthesis, characterization and photodynamic activity of new antimicrobial PVC based composite materials*, European Polymer Journal, Volume 160, 110805

12. Fonti, V., Di Cesare, A., Šangulin, J., Del Negro, P., & Celussi, M. (2021). *Antibiotic resistance genes and potentially pathogenic bacteria in the central Adriatic Sea: are they connected to urban wastewater inputs?* MDPI, in the framework of the special issue of Water (ISSN 2073-4441), section Wastewater Treatment and Reuse, Water, 13, 3335.
13. Figueredo, F., Girolametti, F., Aneggi, E., Lekka, M., Annibaldi, A., Susmel, S. (2021). *Plastic electrode decorated with polyhedral anion tetrabutylammonium octamolybdate [N(C 4 H 9) 4] 4 Mo 8 O 26 for nM phosphate electrochemical detection*, Anal Chim Acta .;1161:338469. doi: 10.1016/j.aca.2021.338469. Epub 2021
14. Marija Kvesić, M., Vojković, M., Kekez, T., Maravić, A., Andričević, R. (2021), *Spatial and Temporal Vertical Distribution of Chlorophyll in Relation to Submarine Wastewater Effluent Discharges*, MDPI, in the framework of the special issue of Water (ISSN 2073-4441), section Wastewater Treatment and Reuse, Water, 13 (15), 3335.
15. Antonacci, A., Zappi, D., Giardi, M. T., & Scognamiglio, V. (2021). *Photosynthesis-based biosensors for environmental analysis of herbicides*. Case Studies in Chemical and Environmental Engineering, 100157.
16. Antonacci, A., Bertalan, I., Giardi, M. T., Scognamiglio, V., Turemis, M., Fisher, D.,& Johanningmeier, U. (2021). *Enhancing resistance of Chlamydomonas reinhardtii to oxidative stress fusing constructs of heterologous antioxidant peptides into D1 protein*. Algal Research, 54, 102184.
17. Giardi, M. T., Zappi, D., Turemis, M., Varani, G., Celso, F. L.,Barone, G., ... & Scognamiglio, V. (2021). *Quantum dots functionalised artificial peptides bioinspired to the D1 protein from the Photosystem II of Chlamydomonas reinhardtii for endocrine disruptor optosensing.* Talanta, 224, 121854.
18. Scognamiglio, V., Giardi, M. T., Zappi, D., Touloupakis, E., & Antonacci, A. (2021). *Photoautotrophs–Bacteria Co-Cultures: Advances, Challenges and Applications.* Materials, 14(11), 3027.
19. Susmel.S, Baldrighi, E., Krzelj, M., Bilic, J., Scognamiglio, V., Celussi, M., (in progress, 15 May 2022). Special Issue *The Impact of Treated Urban Wastewaters and Flood Discharge on the Quality of the Bathing Water*, MDPI, special issue of Water (ISSN 2073-4441), section Wastewater Treatment and Reuse.