D.5.3.1 – Final Governance guidelines

Document Control Sheet

Project number:	10044130
Project acronym	WATERCARE
Project Title	Water management solutions for reducing microbial environment impact in coastal areas
Start of the project	01/01/2019
Duration	30 months

Related activity:	5.3 – Policy actions on coastal waters management to respect WFD and MSFD
Deliverable name:	Final Governance guidelines
Type of deliverable	Report
Language	English
Work Package Title	Smart system to support governance decision processes in Water Management of Adriatic basin
Work Package number	5
Work Package Leader	SPLITSKO-DALMATINSKA ŽUPANIJA

Status	Final
Author (s)	**Authors:** Luigi Bolognini, Sara Giorgetti - **PP2-Marche Region** **Co-authors:** Pierluigi Penna, Fabrizio Moro, Christian Ferrarin, Elena Manini, Elisa Baldrighi, Federica Grilli, Mattia Betti, Giordano Giuliani, Alessandra Campanelli, Mauro Marini - **LP - CNR IRBIM** Giovanna Marrama, Luca Iagnemma – **PP3-Abruzzo Region** Antonella Penna, Fabio Ricci, Silvia Casabianca, Samuela Capellacci - **PP4-UNIURB** Martin Bucan, Katarina Suta – **PP5-SDC** Ivo Duracic, Dolores Grilec - **PP6-DNR** Maja Krzelj, Marin Ordulj – **PP7-UNIST** Marija Šikoronja – **PP9-CW** Vedrana Špada, Josipa Bilic – **PP10-IV (former PP8-METRIS)**
Version	1
Due date of deliverable	31st December 2021
Delivery date	31st December 2021

DOI:10.5281/zenodo.6221594

INDEX

1. INTRODUCTION[1]

The Italy-Croatia Program is the financial instrument to support cooperation between the territories of the two member states of the European Union bordering the Adriatic Sea.

Financed with European funds, it allows regional and local stakeholders to exchange knowledge and experience, develop and implement products and services of pilot actions, support investments through the creation of new business models, test the feasibility of new policies, with the ultimate goal of improving the quality and living conditions of citizens residing in the area.

The Interreg VA Italy-Croatia 2014-2020 cross-border cooperation program was adopted by the European Commission with Decision C (2015) 9342 of 15 December 2015. With an area of over 85,500 square kilometers and a population of over 12.4 million inhabitants the eligible area of the Italy-Croatia Program extends along the two shores of the Adriatic, thus making it a maritime cross-border program.

The general objective of the Program is to increase the prosperity and "blue" growth potential of the area, stimulating the creation of cross-border partnerships capable of bringing about tangible changes.

The Program is divided into four Priority Axes, which are divided into specific Objectives.

The WATERCARE project "WATER Management solutions for reducing microbial environment impact in Coastal AREas" is part of the "INTERREG Italy-Croatia" cross-border cooperation program.

In particular, the WATERCARE project belongs to Priority Axis 3 "Environment and Cultural Heritage" and to the Specific Objective OS 3.3: to improve the environmental quality conditions

[1] ***Sources***:

https://www.italy-croatia.eu/home

https://www.regione.veneto.it/web/programmi-comunitari/cte-italia-croazia

2014 - 2020 Interreg V-A / Italy - Croatia CBC Programme / Call for proposal 2017 Standard – WATERCARE / Priority Axis: Major change Environment and cultural heritage / Application Form - Version date: 10/02/2021 15.33.57 of maritime and coastal areas by using sustainable and innovative technologies and approaches.

Adriatic sea offers an overall good quality of water in relation to Mediterranean context and this represents a strength point and an opportunity, but at the same time the increased anthropic pressure, in particular during touristic seasonal peaks and the inefficient and fragmented wastewater management systems, due to the Adriatic sea physical geographic characteristics, represent a weakness and threat points.

In Italy, Croatia and Europe, the state of quality of the bathing waters and their classification determined by the monitoring required by Directive 2006/7/EC is presented primarily with a class of excellent quality; only near rivers and streams can be found classifications of bathing water with lower quality. Episodes of rain of significant intensity, also as a negative effect caused by climate change, induce floods and significant consequences on river and sewage systems, with medium / long-term impact on bathing water in many Italian and Croatian coastal areas, where the network sewer can discharge directly into the sea.

During these events, the microbial contamination significantly affects the quality of bathing water with a negative impact on tourism and related activities of coastal towns.

WATERCARE aims to improve microbial and environmental quality and resource efficiency in bathing and coastal waters reducing the microbial contamination by using innovative tools in wastewater management and treatment.

This was the concept behind the project: in fact, these problems of faecal water contaminations are common to both Adriatic coasts and must be resolved to safe and preserve human health, environment and tourism activities, representing fundamental economic resources for whole IT-HR Programme area.

In addition, as indicated in the WFD 2000/60/EEC, bathing waters are considered protected areas and therefore, they need safeguards much more targeted to their suitable use.

The project will bring into practice two essential aspects for a reliable WFD implementation, which represent a fully innovative phase:

- an estimation of microbial contamination associated to environmental status assignment and natural variability (meteorological conditions), at the moment entirely absent in the scenario of the governance processes with provisional forecasting of faecal dispersion along coastal areas;

- the response to the problem by means of the infrastructures ad hoc and the implementation of a Water Quality Integrated System that correlate the environmental conditions and impacts generated by the spillage of wastewater.

The deployment of an innovative tool would allow a reduction of the negative environmental impact (microbial and healthy) and the designing of new rules in the future, in order to set up adapted management systems, if a contamination exists. The design innovation is also significant considering specific sites with different characteristics that can be represented and driven by the same management project.

Control target areas were also considered in order to use the alert network system in other places with similar problems.

In conclusion, the results achieved by the WATERCARE project:

- contribute to the implementation of the European Union environmental legislation with an innovative pilot scale management tool that can provide useful information to the operators of wastewater in order to reduce the faecal bacterial load along the sewers and the bathing and coastal waters.
- improve the water management of urban areas through the warning alert system for health and environmental protection authorities.
- will also contribute to the updating and implementation of the EU environment policies through proper actions to really improve the water quality also after the end of the project.

Cooperation between public administration (here representing local, regional and national authorities), private sector (companies) and science and research institutions, sharing knowledge across the Adriatic Sea and applying of these innovative approaches in different Italian and Croatian coastal areas, is expected to provide for progress on the improvement of the water quality of the coastal areas.

2. STRATEGY OF THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT[2]

2.1 Sustainable development and 2030 Agenda

Sustainable development is understood as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Gro Harlem Brundtland, 1987).

This concept becomes concrete when three very specific aspects are integrated and mutually support each other:

1. economic sustainability: creating lasting growth of economic indicators, generating income and jobs and supporting populations over time, enhancing their territorial specificities and effectively allocating resources;

---

[2] ***Sources***:

United Nations:

https://www.un.org/sustainabledevelopment/

https://www.un.org/sustainabledevelopment/development-agenda/

European Commission:

https://ec.europa.eu/info/publications/reflection-paper-towards-sustainable-europe-2030_it

Ministry of Ecological Transition:

https://www.mite.gov.it/pagina/la-strategia-nazionale-lo-sviluppo-sostenibile

Territorial Cohesion Agency:

https://www.agenziacoesione.gov.it/comunicazione/agenda-2030-per-lo-sviluppo-sostenibile/

https://www.agenziacoesione.gov.it/dossier_tematici/agenda-onu-2030-per-lo-sviluppo-sostenibile/

Marche Region:

https://www.regione.marche.it/Entra-in-Regione/Sviluppo-Sostenibile

https://www.regione.marche.it/Entra-in-Regione/Sviluppo-Sostenibile/Documenti#Atti-regionali

https://www.regione.marche.it/Entra-in-Regione/Sviluppo-Sostenibile/Documenti#Strategia-nazionale-Sviluppo-sostenibile

https://www.regione.marche.it/Entra-in-Regione/Sviluppo-Sostenibile/Documenti#Agenda-ONU-2030

2. social sustainability: ensuring conditions of human well-being (safety, health, education, democracy, participation, justice) equally distributed and pursuing social inclusion, gender equality and respect for human rights;

3. environmental sustainability: safeguarding the planet using natural resources that does not damage their level of quality and reproducibility over time.

The goal is to build a more equitable, healthy and harmonious society for all. It is a universal call for action to end poverty, protect the planet and improve the lives and prospects of all, everywhere.

In particular, the 2030 Agenda for Sustainable Development is an action program signed on 25 September 2015 by the governments of the 193 member countries of the United Nations. Approved by the UN General Assembly, it is made up of 17 Sustainable Development Goals, SDGs - (Figure 2.1) included in a broader action program consisting of 169 goals, to be achieved by 2030, in environmental, economic, social and institutional fields.
This action program represents the common basis to start from, to achieve a sustainable world from an environmental, social and economic point of view.

Figure 2.1 - 1 Sustainable Development Goals of the 2030 Agenda (United Nations, 2015).

An interesting and innovative aspect that distinguishes the 2030 Agenda is the one related to the research, understanding and enhancement of the interconnections between different objectives and sectors, in order to develop more effective and coherent strategies and policies, finally abandoning the obsolete and ineffective sectoral vision.

Each country belonging to the UN is called to activate the above path and is periodically assessed by monitoring the implementation status of Goal and Target, through a set of over 240 reference indicators.

Talking about Europe, sustainable development has long been deeply rooted in European policies: in fact, over the course of 40 years, the European Commission has implemented stricter environmental standards and ambitious climate policies, inaugurating a far-sighted debate on sustainable development which is part of the broader reflection launched by the White Paper on the future of Europe of March 2017.

The EU has everything it needs to improve its competitiveness, invest in sustainable growth and stimulate action by governments, institutions and citizens, setting an example for the rest of the world. Using the United Nations Sustainable Development Goals (SDGs) as a guiding tool, the European Commission published a reflection paper in 2019, which identifies the key tools to foster the transition to sustainability by 2030.

The Sustainable Development Goals will continue to inspire the Commission's political decision-making process and guide the development of the European Growth Strategy, without however excluding other political priorities and without imposing on Member States measures to achieve the SDGs collectively and at Community level. This approach should leave more freedom for Member States, including regional and local authorities, to decide whether and how to adapt their activities to achieve the Sustainable Development Goals.

The European Commission, during the opening speech of the plenary session of the European Parliament (July 2019), presented a rich action program to be implemented for the next five years, which clearly shows the will to achieve the sustainable development goals, also in relation to the Paris agreement on climate change, and prepares the ground for its own global strategy for the years 2019-2024.

2.2 2030 Agenda in Italy

Each country is required to develop its own national strategy for sustainable development.

In Italy, the “Benessere Italia” control room was set up, an organ of the Prime Minister's office which has the task of coordinating, monitoring, measuring and improving the policies of all the Ministries in the name of citizens' well-being. The control room will be a tool that will allow the government to promote equitable and sustainable well-being through the definition of new approaches and new policies.

The Italian programmatic lines are developed in five macro-areas:

- sustainable regeneration of territories,
- mobility and territorial cohesion,
- energy transition,
- life quality,
- circular economy.

The objectives of these macro-areas are to place the person at the centre of everything and aim at promotion of healthy lifestyles, definition of balanced life times, design of fair living conditions, promotion of actions aimed at human development, continuous training.

The Italian coordination tool for the implementation of 2030 Agenda is represented by the National Sustainable Development Strategy (SNSvS), approved by CIPE with Resolution no. 108/2017. The provision, to be updated every three years, "*defines the national reference framework for planning, programming and evaluating environmental and territorial processes to implement the sustainable development goals of the United Nations 2030 Agenda*".

The implementation of National Sustainable Development Strategy must be linked with existing national planning documents and the proposed actions and operational tools must be reconciled with the already existing and binding objectives at EU level.

The SNSvS 2017-2030 is the main tool for the creation of a new circular economic model, with low CO_2 emissions, resilient to climate change and other global changes due to local crises, such as, for example, the loss of biodiversity, the modification of fundamental biogeochemical cycles (carbon, nitrogen, phosphorus) and changes in land use. It is based on a multidimensional approach to overcome economic, environmental and social inequalities and thus pursue sustainable, balanced and inclusive development. This approach involves the use of a wide range of tools, including fiscal policies and structural reforms. The plan updates the previous "Environmental action strategy for sustainable development in Italy 2002-2010", but broadens its range of action, integrating the objectives contained in the United Nations 2030 Agenda.

The five areas of intervention in which the strategy is structured correspond to the "**5Ps**" of sustainable development proposed by the 2030 Agenda, each of which contains Strategic Choices and Strategic Goals for Italy:

• **People**: fight poverty and social exclusion and promote health and well-being to guarantee the conditions for the development of human capital;

• **Planet**: guaranteeing sustainable management of natural resources, counteracting the loss of biodiversity and protecting environmental and cultural assets;

• **Prosperity**: affirming sustainable models of production and consumption, guaranteeing quality employment and training;

• **Peace**: promoting a non-violent and inclusive society, without forms of discrimination. Countering illegality;

• **Partnership**: to intervene in various areas in an integrated manner.

There is an explicit reference to the profound interrelation between economic dynamics, social growth and environmental quality, aspects also known as the three pillars of sustainable development.

As for a fundamental aspect of sustainable development, namely the participation of civil society, the Italian Alliance for Sustainable Development (ASviS) was born in Italy in 2016: this is an organization created on the initiative of the Unipolis Foundation and the University of Rome "Tor Vergata”, which has as its purpose the dissemination, at a social and institutional level, of knowledge and awareness of the importance of the 2030 Agenda for sustainable development.
The ASviS annually draws up a report which presents both an analysis of the state of progress of Italy with respect to the 2030 Agenda and the Sustainable Development Goals, and proposals for the development of strategies that can ensure the economic and social development of the Country.

2.3 2030 Agenda in Marche Region

With the Regional Council Resolution no. 250 of 8/3/2021, which approved the "Preliminary Document for the Regional Strategy for Sustainable Development", Marche Region started the process of defining the SRSvS, through adequate information and participatory processes, in implementation of the 'art. 34 of Legislative Decree no. 152/2016, building a collective process capable of creating synergies and integrations, starting from existing tools.

The SRSvS contributes, at a local level, to the implementation of the SNSvS and the 2030 Agenda, wanting to overcome the sectoral approach, because it is developed on the basis of four areas of action: social, environmental, economic and institutional. The SRSvS is a three-year document that aims to ensure the consistency of regional and national policies.

There are five identified strategic choices and in each of them a series of objectives are defined to be pursued, at the regional level, also through the unity of intent of the planning and programming action:

1. prevent and reduce the risk of disasters by reducing exposure to hazards and vulnerability, increasing the respond and recover capacity, thus strengthening resilience;

2. addressing climate change and related social and economic inequalities;

3. recognize the value of ecosystem services and thus protect biodiversity;

4. pursue equity, aiming towards the elimination of poverty, of inequality of development benefits and the creation of dignity conditions for every person life;

5. promote industrial research and technological innovation towards the development of new sustainable production solutions, in terms of innovation and energy efficiency, reduction of emissions into the environment, recovery and reuse of by-products and waste, development of biocompatible productions.

All the structures of Marche Region contribute to achieve the objectives through the implementation of multiple strategic interconnected choices, converging towards a single regional objective, making their achievement more concrete.

The first step was, in fact, the identification of a multi-actor and multi-sector governance able to consider the different dimensions of the development of the territory and to manage and coordinate the actions of the various stakeholders (Region, Local Authorities, associations, individuals, etc.) towards common goals.

2.4 Connection with WATERCARE project

As part of the strategy for sustainable development and following the objectives that 2030 Agenda sets, as in the previous paragraphs mentioned in a general way, WATERCARE project and its results constitute valid and concrete tools in relation mainly to 3 goals indicated in the Agenda itself, described in detail in the tables at the end of this paragraph.

In fact, the specific objective of the project, which, let us not forget, is based on an Italian-Croatian international cooperation (see implementation tool 6.a), is to improve the environmental quality conditions of the sea and the coastal area using sustainable and innovative technologies and approaches and this is none other than one of the targets of goal number 6 of the 2030 agenda. This target, in fact, provides for the improvement of water quality by reducing pollution, eliminating drainage practices uncontrolled and minimizing the release of chemicals and hazardous materials, halving the percentage of untreated wastewater and substantially increasing recycling and safe reuse globally (see target 6.3).

Furthermore, as foreseen in the implementation tool 6.a, the first rainwater collection tank, foreseen in the WATERCARE, constitutes a water collection system prodromal to the treatment of particularly polluted water such as that collected in the first minutes from the beginning of the overflow.

The WQIS and the alert tool that arise from the project, thanks to the fact that they can be made available to local communities as forecasting tools, will be useful to strengthen their participation in improving water and sewage management (see implementation tool 6.b).

This last aspect links WATERCARE project to goal number 13 of the 2030 Agenda, since, given a specific knowledge of the territory and the scenarios that could arise on it, what will be the quantity of urban wastewater spilled, the charge microbial spilled and present in bathing waters and the duration of pollution in the area, it will be possible to strengthen resilience and the ability to adapt to climate-related risks (see target 13.1), integrating national policies, strategies and plans measures to combat climate change (see target 13.2) and having a valid early warning tool available (see target 13.3).

Thus, by containing urban wastewater discharges (first rainwater collection tank and upgrading of existing plants and infrastructures), reducing the flooding of such wastewater into the sea and, consequently, the microbial load spilled in them, thanks to the widespread use of the WQIS and the alert tool on a local scale, the achievement of the targets set by goal number 14 of the 2030 Agenda will also be achieved, namely:

• the prevention and significant reduction of marine pollution of all types, in particular that from land activities (see target 14.1);

• the management and protection of marine and coastal ecosystems to avoid significant negative impacts (see target 14.2);

• the protection of at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best scientific information available (see target 14.5);

WATERCARE is therefore configured as an implementation tool useful for increasing scientific knowledge, developing the capacity for research and transfer of marine technology (implementation tool 14.a).

Table 2.4 - 1 Agenda 2030 Goal 6: clean water and sanitation.

GOAL
TARGET
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
IMPLEMENTATION TOOL
6.A By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.B Support and strengthen the participation of local communities in improving water and sanitation management

Table 2.4 - 2 Agenda 2030 Goal 13: climate action.

GOAL
TARGET
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
13.2 Integrate climate change measures into national policies, strategies and planning
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
IMPLEMENTATION TOOL
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

Table 2.4 - 3 Agenda 2030 Goal 14: life below water.

GOAL 
TARGET
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation
14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
IMPLEMENTATION TOOL

14.A Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries
14.B Provide access for small-scale artisanal fishers to marine resources and markets
14.C Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want

2.5 Figures index

2.6 Tables index

3. PROJECT WATERCARE OBJECTIVES[3]

The project is framed into the context of EU common strategic priorities for improving the environmental quality conditions of the sea and coastal waters, using sustainable and innovative technologies and approaches. This measure must be adopted according to the EU Directive 2006/7/CE that regulates the quality level of coastal bathing waters.

WATERCARE project overall objective is to reduce the impact of microbial environment contamination in bathing waters and deriving by high and heavy rainfalls drained in the local sewage network, in accordance with EU Directive 2006/7/CE, and addressing SO 3.3 "Improve the environmental quality conditions of the sea and coastal areas by use of sustainable and innovative technologies and approaches".

Furthermore, WATERCARE had the goal to improve the water quality of urban areas of the cooperation area and support governance knowledge and process on water quality management in pilot area.

To sum up, WATERCARE project:

- developed an innovative Water Quality Integrated System (WQIS) composed by a real time hydro-meteorological monitoring network and by a forecast operational model;

- realized an ad-hoc infrastructure for bathing waters management in a pilot site through a forecast operational model;

- realized feasibility studies in other 4 target sites to improve planning and management of environmental problems of the marine system;

- developed a real-time alert system able to preventively identify the potential ecological risk from faecal contamination of bathing waters due to high unusual local riverine floods and to support governance decision processes in the management of bathing water and touristic related activities.

Main beneficiaries of the project will be public authorities, coastal zone managers and stakeholders (operators of the facilities and tourist services, swimmers and bathers, tourists

[3] ***Sources:***

2014 - 2020 Interreg V-A / Italy - Croatia CBC Programme / Call for proposal 2017 Standard – WATERCARE / Priority Axis: Major change Environment and cultural heritage / Application Form - Version date: 10/02/2021 15.33.57 and citizens). They will be supported in the water management of urban areas in order to avoid and reduce the level of water bacterial contamination in the sea deriving by abundant rainfalls; as well as to limit days and hours when it is forbidden or not recommended to bath in the sea (including WFD and MSFD requirements).

To reduce Escherichia Coli and Intestinal Enterococci's microbiological contaminations in coastal waters and consequently to improve wastewater management of urban areas through the warning to environmental protection authorities, following WATERCARE's protocol activities:

- microbiological and chemical analytical determinations;
- use of instruments for meteorological (rain gauges) and flood measures (water flows);
- realization of a new infrastructure to mitigate or eliminate the contribution;
- application of a new system for assessing the quality of bathing sea water;

contributed to the Result indicator improving the environmental quality conditions of the sea and coastal areas through innovative technologies and approaches in IT-HR Programme area.

Above-mentioned bacterial contaminations were monitored at the pilot site in Fano-Marche and in 4 target areas: Pescara river-Abruzzo, Rasa river-Istria, Cetina river-Split and Neretva river-Dubrovnik. This allowed to evaluate benefits provided by the project activities and verified in the real how useful and efficient are the innovative solutions adopted.

3.1 Project specific objective 1: Water Quality Integrated System (WQIS)

WATERCARE allowed the development of a Water Quality Integrated System (WQIS) to correlate the meteorological events and drainage system response in relation to microbial impact on bathing waters.

The model provided a real-time alert system of sewage water quality and flow rate into the sea, as well as the faecal bacterial dispersion in coastal waters.

WATERCARE modelling system is composed by:

1. a meteorological, hydrological and microbiological monitoring network based on sensors, analyses and alert system along sewers, river, stream and bathing coastal waters,

2. a numerical model of the coastal waters (FOM) to simulate and forecast bacterial dispersion in bathing waters.

The first one is based on meteorological database, which receives real time data from the low-cost monitoring network that provides both rainfall and sewer water level data.

Meteorological and hydrological parameters evaluate surface run-off phenomena; further information are collected reporting the time lapse between each rainfall event and the previous one. Data collected by bacteriological analysis are stored into a specific monitoring database together with meteorological/hydrological data.

These collected records are also used to provide a real-time Alert System to support the optimal management of river and coastal water quality and able to identify through the FOM the bacterial dispersion, and so, the critical areas where the bathing should be forbidden.

3.2 Project specific objective 2: New infrastructure realization of sewage storage tank (Implementation of the WQIS)

Within WATERCARE, in Fano pilot area, a new infrastructure realization of sewage storage tank was designed and realized. Tank's specific objective is to retain the first rainwaters during the rainstorm that are mixed with the wastewater sewerage system; such wastewaters have the greatest microbiological pollutants loads derived from the drainage runoff at the beginning of the rainy event.

The amount collected will allow, if the meteorological event is quantitatively important, and therefore impossible to be contained by the sewage system, to minimize the impact on the receptor river or coastal waters used for bathing.

It’s now possible to verify exactly the positive impact of tank infrastructure in environmental terms and to measure the amount of pollutants released into the environment and not properly treated in the purification plant.

Monitoring was implemented through the installation of sensors. They transmit all measurements to a specific remote-control system that allows monitoring and processing of data in order to spill into sewage network of the second rainwaters, which are characterized by a very low physical-chemical and microbiological pollutants loads.

Therefore, the result reached thanks to this specific objective consists on a significant improvement of the bathing water quality, in the first place avoiding to discharge the most polluted wastewater and then letting a better wastewater treatment when the rainstorm is ended.

3.3 Project specific objective 3: Real-time alert system

This specific objective carried out the realization of an integrated and smart WATERCARE decision processes system to help the responsible authorities and stakeholders (operators of the facilities and tourist services, swimmers and bathers, etc) to improve the management of urban water areas through a smart system of support for the control on meteorology, bacterial load and discharge of overflow sewerage network.

The project design innovation is significant for the consideration of specific sites with different characteristics, which can be represented and driven by the same management project. For this reason, any action aimed at quantifying the influence of natural factors on quality evaluations has a relevant impact on management practices and monitoring planning.

3.4 Outputs and results durability

The WQIS developed by WATERCARE will continue also after the project in order to allow Adriatic cities to manage in case of microbial and overflow emergencies and to interact in coordinate way to manage microbial contamination in coastal waters. The forecast operational model will be maintained operative by CNR.

UNIURB, UNIST, SDC, DNR, CW, METRIS, MARCHE REGION and ABRUZZO REGION will guarantee the access to monitoring data. The monitoring of the efficiency of the storage tank in the pilot area will be maintained by ASET.

The Alert Tool to support governance decision processes will be maintained operative and ensured the correct operation of the system by CNR using own financial resources or through funds received from end-users.

3.5 Outputs and results transferability

WATERCARE is based on the results of other approved European projects, where applied simulations and integrated modelling have been used for a better management of coastal waters and river loads.

With WATERCARE, specific needs of the Adriatic Sea and its peculiarities were taken into account, potentially extending the use of WQIS to the entire Mediterranean basin.

The WATERCARE pilot site was tested in Fano, but similarly it could be replicated to other sites with the same issues through simple guidelines disseminated at the end of the project lifetime.

The guideline for a Smart Alert system can be transferred to other Italian and Croatian regions and counties as an example to optimize of bathing water management.

3.6 Project Partners (PP)

Environment protection and in particular the improvement of the environmental quality conditions of the sea and coastal areas by use of sustainable and innovative technologies and approaches is an objective for which the adoption of the cross-border approach is to be considered essential.

It will be never possible to reach positive results under quality seawater theme if municipalities, cities, governments and other regional or national public authorities act alone and without implementing common and coordinated actions aimed to solve, or at least to reduce, the growing seawater contamination problem.

Furthermore, this is even truer in cases, and the Adriatic Sea is one of those, where geographical conditions limit the seawater flows circulation and their exchange with "new" seawater making worse the effects generated by the combination of polluting human activities and climate events such as heavy rainfalls.

Italy and Croatia, as the two biggest countries in terms of kilometres of coasts along the Adriatic Sea, also represent the major seawater polluters and therefore they must collaborate to implement efficient and effective solutions to the common problem.

Cross-border cooperation is also necessary because Italian and Croatian organisations are not placed on the same level in terms of innovative and sustainable technologies, methods and approaches to use for environment protection and wastewater treatment. Therefore, thanks to

WATERCARE, it was possible to share and implement the latest practices and so provide benefits to:

- all partners involved in the project, who could increase their knowledge and competences and transfer it among different types of institutions;

- target groups:

public (in general), which health status is better guaranteed;

public authorities and agencies not involved in the partnership, will be informed on results, outputs and technologies reached and used during the project.

In WATERCARE all PPs contributed for a good project development participating in definition of objectives, activities, their division in WPs (Work Packages) and their timing, outputs to obtain and budget estimations. This is derived from the identification of experiences and abilities of each PP and from the results they want to achieve. Operating in a joint mode allowed to guarantee a real and effective participation of all PPs, ensuring a forward step towards sustainability of whole area.

WATERCARE implementation overall responsibility was in charge of a LP (Lead Partner), that guaranteed the correct on-going implementation under administrative, financial and operative aspects.

The project, as just written, was divided into Work Packages and each WP was assigned to one partner (WP leader) that assured its implementation. WP leaders coordinated activities under their respective WP, where several partners will take part for the operative realization. WATERCARE staff was accurately defined avoiding unnecessary duplication of functions and taking into account the specific partner role in the project. During activities implementation, each partner's staff involved was coordinated by WP leaders and cooperated with the other partners' staff involved in the same activity or WP. Cooperation was realized through a regular exchange of information and using different instruments, such as e-mail and conference call.

Table 3.6 - 1 Partners in WATERCARE project (LP = Lead Partner; PP = Project Partner).

Partner role/number	Partner name	Partner country
LP	NATIONAL RESEARCH COUNCIL - NRC	ITALY
PP1	ASET SPA	ITALY
PP2	MARCHE REGION	ITALY
PP3	ABRUZZO REGION	ITALY
PP4	UNIVERSITY OF URBINO "CARLO BO"	ITALY

PP5	COUNTY OF SPLIT-DALMATIA	CROATIA
PP6	DUBROVNIK AND NERETVA REGION	CROATIA
PP7	UNIVERSITY OF SPLIT	CROATIA
PP8	METRIS RESEARCH CENTRE	CROATIA
PP9	CROATIAN WATERS	CROATIA

3.6.1 NATIONAL RESEARCH COUNCIL – NRC (LP)

CNR has a long recognized experience in marine studies both in the coastal and open oceans and employs a multi-disciplinary group of specialists working in many fields of research. CNR is very active in environmental monitoring and management and in territory resource safeguard. The activities of research, technology applications and training are focused on the application of innovative method (remote sensing, environmental modelling, climatic measurements) for data collection, dbase organizations and ecosystems investigations at different time and spatial scales.

The studied areas are mainly the Adriatic Sea and all coastal zone. The quality of transitional environments is assessed by studying hydrological and ecological processes. CNR will conduct physical, chemical and biological monitoring to assess the quality of the waters and the state of coastal zones. CNR will implement a meteorological governance forecast model based on a low cost and open source weather stations network.

Web site:

https://www.cnr.it/it/istituto/122/istituto-per-le-risorse-biologiche-e-le-biotecnologie-marine-irbim

3.6.2 ASET SPA (PP1)

ASET is a company that is dedicated to provide local public services for 18 Municipalities, owners of the company. Services entrusted are as follows: integrated water service, production and distribution of drinking water, management of all networks and systems, management of sewerage and sewage treatment plants, chemical and microbiological laboratory service for internal use and third parties and others.

ASET has developed and constantly updates, an Integrated Management System for Quality, Environment and Health and Safety at Work.

ASET has structured, documented, implemented and maintains its own Integrated Management System in order to ensure the planning, implementation, monitoring and improvement of the main processes. So services provided meet the needs of the "system customers "and are carried out by company personnel in compliance with the mandatory standards relating to Health and Safety in the workplace and in environmental matters.

Web site:

http://www.asetservizi.it/servizio-idrico-integrato/informazioni-generali/programma-cooperazione-transfrontaliera-interreg-v-a-italia-croazia-progetto-watercare/

3.6.3 MARCHE REGION (PP2) - DEPT. OF PROTECTION OF WATER AND PROTECTION OF SOIL AND COAST

Protection of Water and Protection of Soil and Coast Department is in charge of water planning and implementation of WFD and MSFD.

It also:

- Manages and upgrades the Protection of Water Plan and the Regional Plan at Central Apennines River Basin level, as Marche Region belongs to this RB.

- Plans water resources monitoring activities through Programmes that are implemented by the Environmental Agencies on fluvial, coastal, lacustrine and underground Basin;

- Directs and verifies infrastructural interventions scheduling related to water supplying and distribution and to urban and industrial wastewater storage and treatment;

- Directs, manages and plans bathing waters protection's programmes and regulation activities;

- Evaluates measures to be adopted in order to reach quality's objectives about underground and surface waters;

- Selects and plans interventions aimed at protecting water resources;

- Plans and realizes interventions about river hydro-morphological topics.

Web site:

https://www.regione.marche.it/Regione-Utile/Ambiente/Tutela-delle-acque/Progetti-Europei#WATERCARE

3.6.4 ABRUZZO REGION (PP3) - MARITIME WORKS AND MARINE WATER SERVICE - DEPT. OF INFRASTRUCTURES, TRANSPORTS, MOBILITY, NETWORKS AND LOGISTICS

The Maritime Works and Marine Water Service is part of the Infrastructures, Transports, Mobility, Networks and Logistics Department of the Abruzzo Region. It has institutional expertise on coastal erosion and coastal protection, Marine Strategy, ICZM, Water quality and marine ecosystems, Port infrastructures. The Service has available a territorial Coastal Information System, realized through eight SW e HW positions. In 2001, it defined the map of the geomorphologic vulnerability and realized feasibility studies on most vulnerable areas. Every year, it elaborates a report on water sea quality, based on chemical, physical, bacteriological and ecological data as sample of the regional costal water. The Service is responsible for monitoring water quality and sea pollution and planning recovery actions. The Service has competences and know how relevant for the project, thanks to the experience in management and coordination of EU projects acquired by the staff during the last years.

Web site:
http://www.regione.abruzzo.it/content/programma-di-cooperazione-transfrontaliera-interreg-v-italia-croazia-progetto-watercare

3.6.5 UNIVERSITY OF URBINO "CARLO BO" (PP4) - DEPARTMENT OF BIOMOLECULAR SCIENCES (DISB)

UNIURB carries out research activity on molecular ecology of marine microbial species; marine molecular biotechnology and development of innovative molecular tools for the monitoring of harmful blooms at coastal systems; monitoring activity at regional level of coastal system (northern Adriatic Sea, Mediterranean Sea). UNIURB is in charged of monitoring of water quality of Pesaro coastal area since 1984 and publishes results on its web site monthly, Stato delle Acque. It has extensive experiences for the project: it conducts research in North Adriatic Sea focusing on biogeochemical cycles, marine productivity and the increasing pollution of coastal environment. Also,it has experience on the evaluation of HABs (harmful algal blooms) cyst impact on coastal ecosystem and further developing of HAB events; assessment of ecological risk associated with the transport of microorganisms; sampling methods and protocols for the application of molecular methods to HAB species and cyst monitoring.

Web site:
https://www.uniurb.it/ateneo/persone-e-strutture/dipartimenti/dipartimento-di-scienze-biomolecolari-disb

3.6.6 COUNTY OF SPLIT-DALMATIA (PP5)

Split-Dalmatia County is experienced in preparation and implementation of different national and international projects, as project partner or lead partner. Institution has competent staff successful in implementing multidisciplinary projects that require regional and international cooperation skills. All realized projects were marked as successful by the relevant bodies and European Commission, thus, the County has highly positive results within the field of international and regional projects implementation and has an extensive network of national, regional and local partner institutions.

Field of competence: regional development planning, environmental protection, balanced development of public utilities, County infrastructure, research and development projects in field of green economy.

Web site:
https://dalmacija.hr/programi-gospodarstva/eu-projekti/watercare

3.6.7 **DUBROVNIK AND NERETVA REGION (PP6)** - ADMINISTRATIVE DEPARTMENT FOR COMMUNAL AFFAIRS AND ENVIROMENTAL PROTECTION

DNR through its Department for Environmental Protection and Nature performs activities in the field of environmental protection and nature and sustainable waste management. The Department is in charge of: development and implementation of documents in the field of environmental protection, sustainable development as well as documents of intervention measures in the environment, ensuring the availability of data from the scope of environmental protection, providing information for the national information system, the adoption of a permit and the establishment of the nature protection conditions for the protected areas and the implementation of the previous and major assessments for ecological network interventions in accordance with the Law of Nature Protection, determining requests and giving opinions in the process of drafting spatial plans in the Region, participation in the environmental impact assessment of plans, programs and strategies at national, regional and local level.

Web site:

http://www.edubrovnik.org/projekt-watercare/

3.6.8 UNIVERSITY OF SPLIT (PP7) - UNIVERSITY DEPARTMENT OF MARINE STUDIES

University Department of Marine Studies is the branch and organizational unit of the University of Split that offers undergraduate, graduate and postgraduate studies in marine biology, ecology, technology, fisheries and applied marine sciences. Research staff of the University Department of Marine Studies includes scientists with rich background in national and international projects, in general relating to the impact of fisheries and aquaculture on the Adriatic and Mediterranean marine ecosystem.

Department of Marine Studies has been involved in numerous studies conducted in the open and coastal marine area. The Departments employees are specialists in many fields of research related to the marine environment. Their research is focused on the changes of the marine ecosystems due to climate change and anthropogenic impact.

During the project The Department will be assessing the sanitary quality of the marine water column by conducting the physical and biological measurements.

Web site:

https://www.unist.hr/en/znanost-tehnologija-i-projekti/ured-za-projekte-i-transfer-tehnologije/baza-projekata

3.6.9 METRIS RESEARCH CENTRE (PP8)

METRIS is an operational body founded by Region of Istria and Istrian Development Agency (IDA) Ltd. entrusted with the implementation of R&D and innovative programmes of the Region of Istria. Therefore, METRIS is linked up through powerful databases, sharing knowledge and business partners across the Region and it has an advantage of being connected with all relevant regional stakeholders and national policy makers of different sectors in which it operates. An added bonus is METRIS's connection with industry sector, since its primary role lies in sophisticated field analyses and development in the context of R&D services in area of advance materials and technology aimed at creating sustainable development for the Region. METRIS is ready to contribute in every phase of this project since it has already performed analyses and studies based on water quality, as well as coordinated similar project in which we built and now own a fully functional WWTP pilot based on innovative technologies.

Web site:

https://www.centarmetris.hr/

3.6.10 **CROATIAN WATERS (PP9)** - WATER MANAGEMENT INSTITUTE

Croatian Waters (CW) can participate in the strategical and methodological achievement of the project objective, which is to upgrade water resources management.

Croatian Waters have extensive experience in accession negotiations for EU membership as well as experience in the transitional process and implementation of water directives (Water Framework Directive, WFD).

Croatian Waters traditionally manage water resources and, as the leading national institution, is responsible for all aspects of water management in Croatia as an EU member state, has extensive experience in the WFD implementation and development of RBMPs.

Croatian Waters is the legal entity for water management established under the Water Act and organised according to the territorial and functional principles.

Web site:

https://www.voda.hr/hr/watercare-vodnogospodarska-rjesenja-za-smanjenje-mikrobioloskog-utjecaja-na-okolis-u-priobalnim

3.7 Tables index

4. CURRENT LEGISLATION

4.1 European rules[4]

4.1.1 General principles

The fundamental principles on which the European legislation on bathing water is based take into account the fact that water is a limited natural resource, therefore its quality must be protected, defended, managed and treated appropriately. In particular, surface waters are renewable resources with limited recovery capacity downstream of a negative impact caused by human activities.

The environmental policy of the Community, as written in the introduction to the EC Directive 2006/7, should aim at a high level of protection and contribute to pursuing the objectives of preserving and improving the quality of the environment, as well as protecting the latter and the human health.

Obviously, in order to increase the efficiency and rational use of resources, the EC Directive 2006/7 must be coordinated with other Community legislation in the water sector (Council Directive 91/271/EEC on urban wastewater treatment; Council Directive 91/676/EEC on the protection of waters against nitrate pollution from agricultural sources; Framework Directive for Community Action on Water 2000/60/EC).

4.1.2 Protected areas

The waters designated as bathing waters are listed among the protected areas by Annex IV of the Water Framework Directive, which, at the time of its enactment, obviously referred to Directive 76/160/EEC, still in force at the time.

---

[4] ***Sources:***

DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy;

DIRECTIVE 2006/7/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC;

https://www.minambiente.it/sites/default/files/archivio/allegati/trasparenza_valutazione_merito/informazioni%20ambientali/18_-_direttiva_acque_balneazione.pdf.

The establishment of a register of protected areas, in article 6 of the same WFD, and the monitoring of these areas, in article 8, are nothing more than the practical application of the objectives that the environmental policy of the European Community must pursue, or:

• safeguarding, protecting and improving the quality of the environment;

• the wise and rational use of natural resources.

The foundation on which these objectives are based lies in precaution and preventive action, as well as in the principle of correction at source of damage caused to the environment and the "polluter pays" principle.

Consequently, again in the WFD, the summary of the register of protected areas, to be included in the management plan of each river basin, contains maps that indicate the location of each protected area, as well as the description of the community, national or local legislation that established them (Annex IV point 2).

Furthermore, in the river basin management plan, the Water Framework Directive itself, with reference to protected areas, provides for the inclusion of:

• the specification and cartographic representation of the protected areas, as prescribed by article 6 and annex IV (annex VII, paragraph 3);

• the map of the monitoring networks established for the purposes of Article 8 and Annex V and the cartographic representation of the results of the monitoring programs carried out in accordance with these provisions to verify the status of these areas;

• the list of environmental objectives set.

4.1.3 Specific goals

As written in the fourteenth "considering" of Directive 2006/7/EC, "*The continued importance of a Community bathing water policy is evident each bathing season as it protects the public from accidental and chronic pollution discharged in or near Community bathing areas*... omitted…".

In fact, with Directive 2006/7/EC, implemented by Legislative Decree 30 May 2008, n. 116, the doors are opened to a new system of control and management of the quality of bathing water, which is based on both monitoring and prevention activities and which perfectly reflects the interdisciplinary philosophy aimed at protecting the entire water body, as required by the framework directive on water (2000/60/EC), to which it is inextricably linked.

In order to protect human health, water resources, natural ecosystems and biodiversity, the specific objective to be achieved is the "good" environmental status, at the level of each river basin, with regard to which, therefore, we must proceed to the analysis of the characteristics and impacts and pressures, even potential ones, due to human activities.

Following the provisions of the definition of pollution given by the Water Framework Directive, the legislation relating to bathing, thanks to the profiles of each bathing water, actually carries out a territorial analysis at the level of the entire drainage basin connected to the bathing, in order to prevent or reduce the consequences of pollution, including those from accidental causes.

Within each profile, each section provides information regarding:

• the identification and description of an area of influence as a fundamental unit for the analysis of the characteristics of the hydrographic basin;

• the possible sources of pollution and their ways of diffusion;

• information on land use.

The main sources of microbiological contamination for bathing water are considered to be the so-called point sources (waste treatment systems, emergency drains of the black sewer, flood spillways of mixed networks and discharges of white sewer networks, direct discharges from industrial plants): of these sources, in each bathing water profile, a description should be made, specifying at least the location, number, type, characteristics and type of prevailing discharge.

From all this information, the description of the area that affects the bathing water will derive, thus being able to better evaluate the impacts that insist on it and also being able to correctly manage any chronic criticalities, including cyanobacterial proliferation and/or macroalgae, an environmental phenomenon with a high health impact. It will be possible to focus on anthropogenic activity, which, in combination with weather and climate changes, can favor an increase in the rate of eutrophication.

Another fundamental objective of the EC Directive 2006/7 is that of information to citizens: it is therefore good that, for each bathing water, the area of influence is shown on a map accompanied by all its characteristics (limits of the influence itself, location of pollution sources, information on the extent of discharges, concentrations of bathing water quality parameters).

4.2 National rules (Italy)[5]

The Italian national rules governing bathing constitute the transposition of the European rules, which have already been discussed in the previous section (4.1).

As early as April 2006, in the environmental code (Legislative Decree no. 152/06) the condition was set, according to which the Regions, for the waters that were still unsuitable for bathing, should transmit, to the Ministry of the Environment and the Protection of the Territory and the Sea, all information relating to the causes of non-bathing and the measures that were intended to be adopted to remedy this non-compliance.

However, only in 2008, with Legislative Decree no. 116, the implementation of the EU directive is achieved with a specific complete national standard, which will then be better defined, two years later, with the Ministerial Decree of 30 March 2010, modified, in turn, with a further Ministerial Decree on 19 April 2018.

In support of the national regulations already mentioned, in 2014 the Higher Institute of Health publishes two guidelines for the management of Ostreopsis cf. Ovata blooms and Cyanobacteria (ratios number 14/19 and 14/20, respectively), in relation to bathing and other recreational activities practiced in marine-coastal and lake environments.

---

[5] ***Sources:***

Legislative Decree of May 30th, 2008, n. 116 "Implementation of Directive 2006/7/EC relating to the management of the quality of bathing water and repeal of Directive 76/160/EEC";

DECREE of March 30th, 2010 Definition of the criteria for determining the prohibition of bathing, as well as methods and technical specifications for the implementation of Legislative Decree May 30, 2008, n. 116, transposing Directive 2006/7/EC, relating to the management of bathing water quality. (10A06405);

DECREE of April 19th, 2018 Amendment of the decree of 30 March 2010, containing: «Definition of the criteria for determining the prohibition of bathing, as well as methods and technical specifications for the implementation of Legislative Decree 30 May 2008, n. 116, transposing Directive 2006/7/EC, relating to the management of bathing water quality». (18A05529);

ISTISAN report 14/19 Ostreopsis cf. Ovata: guidelines for the management of blooms in marine-coastal environments in relation to bathing and other recreational activities;

ISTISAN 14/20 Report Cyanobacteria: guidelines for the management of blooms in bathing waters;

https://www.arpa.marche.it/indicatori-ambientali.

4.2.1 General principles

The general principle on which the current Italian legislation is based is that of the integrated approach between various innovative tools such as bathing profiles, the forecast of short-term pollution, the classification of bathing water into four quality categories, the role of public participation, information to bathers in real time (through signs and specific information), as well as water monitoring, according to the technical criteria set out in the annexes to the standards themselves.

4.2.2 Specific goals

Going into the detail of the Italian legislation, the Legislative Decree no. 116/08 has the specific objective of protecting human health from the risks deriving from the poor quality of bathing water, also through environmental protection and improvement, integrating (but it would be better to write "defining in detail") what had already been outlined in article 83 of the already cited Environmental Code.

The objective the legislator is aiming for is that all bathing waters come to be classified at least as "sufficient", and that appropriate measures are taken to increase as much as possible the number of bathing waters classified as "excellent" or "good".

The Legislative Decree no. 116/08 establishes the procedures for carrying out:

a) monitoring and classification of bathing water quality;

b) management of bathing water quality;

c) information to the public about the quality of bathing water.

In addition to the provisions of the 2006 Community Directive, Legislative Decree no. 116/08 defines the competences and divides them between the State, Regions and Municipalities. The latter have, in addition to the other powers assigned to them, the obligation to delimit the areas prohibited for bathing, if during the bathing season an unexpected situation occurs which has, or could possibly have, a negative impact on the quality of the water bathing or on the health of bathers.

Furthermore, with the Ministerial Decree of 30 March 2010, the procedures and technical specifications for the implementation of Legislative Decree no. 116/08, specifying what the criteria must be for determining the ban on bathing. In 2018, with a further Ministerial Decree issued on 19 April, the 2010 Ministerial Decree was updated, especially in relation to the evolution of technical-scientific knowledge that has taken place over the years.

It is with the Ministerial Decree of 2010, in fact, that the limit values not to be exceeded were published, for each individual sample taken from marine or inland waters, relating to intestinal Enterococci and Escherichia coli (Annex A) and, in Annex E it was specified in detail, by dividing into sections and fields, what information was useful for defining the profile of each bathing water.

The Marche Region, as well as all the other regions in the Italian territory, makes use of the Regional Agency for Environmental Protection (ARPAM), which, during the bathing season (which, except for exceptions, runs from May to September), monitors the waters of bathing according to an established program, with at least a monthly routine sampling frequency. However, the Agency also carries out additional sampling in the event of critical issues or reports.

4.3 National rules (Croatia)[6]

Croatian legal framework on bathing waters rests on European rules already transposed and previously discussed in chapter 4.1. Bathing waters are classified as protected areas by the Water Act (OG 66/19) and quality management of the bathing waters assures preservation, protection and improvement of surface water quality, and contributes to the protection of the environment and human health.

Hence, on April 24th 2014, according to Article 51 Paragraph 7 of the Water Act (OG 153/09, 56/13), the Government of Croatia adopted Regulation on bathing water quality (OG 51/14), concerning the surface and inland waters. Furthermore, regarding the same, on the 3rd of October 2019 Regulation on water quality standards (OG 96/19) based on Article 47 Paragraph 1 of the Water Act was adopted.

[6] ***Sources:***
Zakon o vodama (NN 153/09, 56/13, 66/19), Uredba o kakvoći vode za kupanje (NN 51/14), Uredba o standardu kakvoće voda (NN 96/19), Uredba o kakvoći mora za kupanje (NN 73/08), Uredba o standradu kakvoće mora na morskim plažama (NN 33/96).

Specific rules are carried out regarding seawater quality. In April 1996 the Regulation on seawater quality standards at sea beaches (OG 33/96) was adopted, whereas in June 2008, based on Article 54 paragraph 1 of the Environmental protection Act (OG 110/07) the new Regulation on sea bathing water quality was adopted. Also, since 1986 continuous implementation of the *Sea bathing water quality monitoring programme* is conducted in the counties along the Adriatic Sea coast. Since the Covid-19 breakout in 2020, the Programme implementation is conducted in a shorter time-space framework. Thus, the Croatian Institute of Public Health issued *Recommendations for bathing at seawater and inland surface waters during the Covid-19* epidemic.

The protection and management of the bathing waters are also comprised within River Basin Management Plan for the period from 2016 to 2021. The Plan prescribes areas and measures for bathing and the monitoring of the same.

Additionally, several information systems that offer information data on inland bathing water and sea bathing water quality including coastal waters are developed. Such systems/databases are updated and monitored by the Croatian Waters and Ministry of Economy and Sustainable development.

4.3.1 General principles

The current Croatian legislation is based on an integrated approach between bathing water monitoring, quality assessments, bathing profiles, the classification of bathing waters into four quality categories, the role of public participation, information to the bathers in real-time as well as technical criteria regarding water testing set out in annexes to the standards themselves and information systems available.

4.3.2 Specific goals

When discussing Croatian legislation in more detail, the objective the legislator is aiming for is that all bathing waters come to be classified at least as "sufficient", and that appropriate measures are taken to increase as much as possible the number of bathing waters classified as "excellent".

Regulation on bathing water quality (OG 51/14) prescribes monitoring, classification of bathing water on inland surface waters, management of bathing water quality and informing the public about the quality of bathing water to preserve, protect and improve the quality of the environment and protect human health. Also, it determines bathing water profiles and measures to be taken in extreme situations and well as indicators for microbiological testing. More specifically, Annex I of the Regulation determines the limit values for the presence of the Escherichia coli and Enterococci as well as a testing method for bathing waters.

Furthermore, Regulation on sea bathing water quality (OG 73/08) prescribes the sea bathing water quality standards for bathing on the coastal beaches which set limit values for microbiological indicators and other characteristics of the sea.

The previously mentioned *Sea bathing water quality monitoring programme* aims at the protection of bathers' health and public health education, beach management to preserve its natural values and sustainable use, monitoring the construction of sewerage systems, and the functioning of existing ones, identification of pollution sources and their rehabilitation, publication of sea quality results for promotion of the tourism, informing the public through information bulletins and web pages. Additionally, every year a *National report on annual and final seawater quality assessment on the beaches of the Croatian Adriatic sea* is issued based on the Seawater quality database. The Report gives an overview on the state-of-the-art regarding the maritime environment, *Sea bathing water quality monitoring programme* implementation, national and European reporting on bathing waters and reports for counties in the Adriatic region.

In this context, Regulation 96/19 can be mentioned. It addresses water quality standards for surface waters, including coastal waters, territorial sea and groundwater, special water protection objectives, criteria for determining water protection objectives, conditions for extending deadlines for achieving water protection objectives, elements for water status assessment, water status monitoring and water status reporting. This Regulation determines the list of substances that represent a potential risk to waters and monitoring of the same according to Article 33 of the Regulation. Also, in the areas of waters suitable for freshwater fish, the microbiological indicators from Annex 8 of this Regulation are monitored.

The monitoring plan of the surface waters, groundwater, coastal and transitional waters is conducted by Croatian Waters. The Plan comprises:

- water sampling and testing for indicators necessary to determine the ecological and chemical status or ecological potential of surface waters and chemical status of groundwaters,
- hydrological measurements to the extent appropriate for determining the ecological and chemical status or ecological potential (quantity and dynamics of river flow, quantity and dynamics flow and retention time for lakes and the amount and dynamics of freshwater flow for transitional waters),

sampling and testing of waters for indicators that are indicative of the quantitative status of waters.

4.4 Regional rules (Marche Region)[7]

4.4.1 General principles

In the Water Protection Plan (PTA) of the Marche Region, approved with DACR n. 145 of 26/01/2010 and published in the BUR Marche n. 20 of 26/02/2010, the general principles on which the protection of both surface and underground waters of the Marche region is based are already defined in Chapter One.

The principles of conservation, saving and reuse of water constitute the basis on which the Plan is based, which has, as its ultimate goal, that of not compromising the extent of the water assets and allowing its use, with priority for drinking water use.

In fact, since the natural resource water is an indispensable public good, it must be not only protected but also improved, so the PTA acts on several fronts:

- in identifying the tools for the protection and conservation of the water resource;
- in the definition of interventions for the protection and rehabilitation of surface and underground water bodies and in the sustainable use of water, identifying the integrated measures for the qualitative and quantitative protection of the water resource, which also guarantee the natural self-purification of water bodies and their capacity to support large and well diversified animal and plant communities according to indigenous principles;

[7] ***Sources:***
DACR n. 145 del 26/01/2010: PIANO DI TUTELA DELLE ACQUE (PTA) – D. Lgs. n. 152/06, art. 121 (B.U.R. Marche n. 20 del 26/02/2010);

DGR Marche n. 419 del 12/04/2021 e precedenti;

• in the regulation of current and future uses.

In particular, the marine-coastal waters of the entire regional coast are identified in the PTA as significant water bodies (second chapter), for which environmental quality objectives are defined and qualitative protection measures are established (fourth chapter).

Furthermore, considering that marine tourism is extremely important for the Marche Region, in the second section of the fourth chapter, discharges are regulated, defining in detail the conditions for authorizing them and precautionary limits are set, aimed at protecting bathing. Thus the rules were defined aimed at the creation of separate sewers, first rain tanks, flood spillways, wastewater treatment plants, reiterating the need to go towards separate sewer networks, for urban wastewater and for rainwater, however, providing for the construction of tanks to collect the more polluted first rain water, to be subjected to appropriate treatments.

All the concepts already expressed by the PTA are taken up every year by the Deliberation of the Marche Regional Council (DGR) relating to the bathing season, which annually covers the period May - September, subject to exceptions established from year to year.

In this act, it is reiterated that bathing waters (BW) represent waters with a specific purpose, the protection of which must pursue the objectives indicated by the Community directives 2000/60/EC (framework directive on water - WFD) and 2006/7/EC (Bathing Water Directive - BWD) and integrate with the objectives of the Marine Strategy Directive 2008/56/EC (Marine Water Framework Directive - MSFD).

In this context, the DGR constitutes an annual update of the cognitive framework requested both by the Management Plans of the Hydrographic Districts, in which Marche are included, and by the Water Protection Plan of the Marche Region, which actually implement the planning of the directives above cited.

4.4.2 Specific goals

Already in the PTA of the Marche Region, introduced in the previous paragraph, the waters intended for bathing are identified as waters with a specific functional purpose (article 13) and a specific definition of them is given:

"*3. They are intended for bathing: all marine-coastal waters, except those in which bathing is prohibited by the Navigation Code and except for the sections corresponding to the mouth of the watercourses, as indicated in the specific resolution of the Regional Council and the following superficial fresh waters: the artificial lake of Castreccioni (MC); the artificial lake of Borgiano (MC); the artificial lake of Fiastra (or Fiastrone) (MC)*".

The adoption and updating of interventions aimed at removing non-compliance situations is already expected in 2010, with reference to the classification of the same bathing waters and the objectives to be maintained or achieved.

In particular, in article 35, the PTA first establishes emission limit values for urban wastewater treatment plants with organic project capacity (COP) of at least 10,000 AE, if they discharge into the surface water bodies of the territorial band included in the 10 km from the sea coast line and from the line of the maximum flooded bank of the lakes intended for bathing, with prescription of adaptation for the existing ones.

Secondly, if "*a coastal or lake stretch of sea is precluded from bathing, even temporarily, by regional and/or municipal measures, due to the spillage of urban wastewater coming directly from sewage and sewerage infrastructures, including flood spillways* ... omissis ... *appropriate adaptation projects must be presented that the AATO will insert in the Area Plan, if deemed appropriate following an evaluation of the effectiveness in terms of costs and benefits*" and this applies to closures both previous and subsequent to the entry into force of the technical standards for implementation at the PTA.

All this to mean that, in the face of continuous monitoring and downstream of closures caused by criticalities that emerged over time, it is necessary to concretely plan significant infrastructural interventions, where they were essential, giving them, however, the due priority, in terms of realization, both from an economic and resolutive point of view.

Entering, then, with regard to discharges of urban wastewater into the sea, Article 36 of the NTA (technical implementation standards) to the PTA provides that they must take place off the coast of coastal defense works parallel to the coast and beyond the extremity of the maritime works perpendicular to it. The only exceptions, which provide for the possibility of having discharges also on the shoreline, are those for which the defense works, perpendicular or parallel to the coast, are more than 400 meters away from it.

Obviously, the discharge ban is foreseen in all port areas, except for existing domestic and similar wastewater discharges, appropriately purified and those of rainwater only, if they are equipped with first rain water collection and treatment systems.

With reference to the first rain tanks, article 43 of the NTA gives precise indications for their construction and their adaptation, which become a priority, again for the purpose of safeguarding bathing water, in correspondence with the discharges of the mixed sewer networks, located (to stay within the bathing area):

- in the 10 km stretch from the outlet into the sea of the rivers Tavollo, Foglia, Misa, Musone, Potenza, Tenna, Ete Vivo, Tesino;
- in other waterways in the stretch of 5 km from the outlet into the sea;
- directly in the sea and in the lakes used for bathing;
- in the emissaries of the lakes used for bathing and drinking water in the stretch of 10 km upstream of the entry point.

Finally, with reference to the protected areas already mentioned, speaking of the Water Framework Directive, the Regional Council periodically provides for the recognition of them also for the purposes of establishing the register of protected areas (Article 117, paragraph 3, of Legislative Decree no. 152/2006) and its periodic updating (paragraph 2 of attachment 9 to the third part of Legislative Decree no. 152/2006), as required by article 81 of the NTA to the Marche regional PTA.

Over the last few years, the Marche Region has been trying to achieve two objectives: to strengthen the protection of bathers, through the guarantee of conformity of bathing waters and to improve the quality of them, by increasing the purification capacity of urban wastewater.

As part of the protection of bathing water and in coordination with all the regulations already analyzed in the previous paragraphs, the annual Resolution of the Marche Regional Council constitutes, as already written, an update of the cognitive framework requested by both the Management Plans of the Hydrographic Districts, and from the Regional Water Protection Plan, implementation of the planning of the European directives in force on the subject.

The adoption of guidelines for the management of the bathing season, made official with the Regional Council Resolution, is part of the ordinary activities of the Regional Administration:

every year, before the beginning of the bathing season, this act must be issued for the necessary indications to the Regional Agency for the Protection of the Environment of Marche and for the forwarding to Local Authorities, for the purpose of preparing the deeds of competence, the affixing of information signs, for the issue of union orders prohibiting bathing for permanently banned waters (YP) and for the identification of coastal stretches not used for bathing.

The annex to the DGR is made up of 8 paragraphs, which define the actions and guidelines to which the Marche Region, ARPAM and seaside, lake and river bathing municipalities must comply in order to implement Legislative Decree no. 116/08.

Pursuant to art. 6 of the same decree, every year, the Region identifies and updates the bathing waters (BW) and their classification, the monitoring sites for assessing the quality of the BW and the duration of the bathing season. In particular, the classification of BWs is proposed by ARPAM to the Marche Region for short routes since mid-October, for approval by 31 December of each year and is subsequently transmitted to the Ministry of Health, through the section "EU Report "Of the Bathing Water Portal (table" Seasonal information "). The classification of the BW, obtained at the end of each bathing season, is verified and approved with the adoption of a specific Executive Decree, using the monitoring data of the four years of the previous bathing seasons. The verification of the classifications takes place between the Ministry of Health, the ARPAM and the Marche Region, in the period October - November and can, at times, lead to the verification/modification of some classifications. Obviously, it is the final classification that is approved and transmitted to the European Commission through the Bathing Waters Portal of the Ministry of Health.

The DGR establishes and indicates the period and duration of the bathing season (SB), as provided for in art. 2 lett. e) of Legislative Decree no. 116/08 and also provides precise criteria for the preparation of the bathing water monitoring calendar according to art. 4, paragraph 1, lett. c) of the same 116 and according to the Ministerial Decree of 30 March 2010: it must be prepared by the end of February of each year and is prepared by ARPAM, which takes care of its execution during the bathing season and uploading it to the website of the Portal of Bathing waters of the Ministry of Health. Specific paragraphs of the annex to the DGR indicate all the monitoring sites periodically sampled by ARPAM.

During the bathing season, the microbiological checks in bathing water are carried out by ARPAM.

For bathing waters classified as poor, on which improvement actions must be implemented, it is necessary to adopt and implement health protection measures and intervention programs to remove the causes that determine the classification; these aspects must be studied in depth with all the subjects/activities that interact in various ways in the hydrological system, altering the quality of the water.

In particular, through specific meetings with the competent regional office, some coastal municipalities have highlighted the need to adopt more effective management measures related to the weather conditions for some waters present along the municipal coastal stretch, through the implementation of specific actions (letter a) of paragraph 4) of art. 8 of Legislative Decree no. 116/08).

These actions concern:

• the adoption of bathing bans in periods of effective compromise of the compliance of the waters subject to the contributions of the mouths of neighboring rivers/streams;

• detailed information to citizens of the conditions in which the health risk of exposure may occur, which is expressed through the adoption of preventive and precautionary measures to prohibit bathing;

• what actions are undertaken and will be adopted to reduce and eliminate the causes of pollution;

• the presence of information boards derived from the profile of the bathing water;

• the methods of reporting the conditions described in appropriate information systems both on the beaches and at the bathing establishments, guaranteeing and ensuring their presence and maintenance.

In order to facilitate and standardize the adoption of acts relating to the closure of the BWs for hygienic-sanitary reasons and the subsequent reopening of the same, in 2019 facsimiles of union orders were produced and approved by Executive Decree, relating to the various types of bathing prohibitions (and subsequent revocation), which can be adopted during each bathing season.

The DGR also lists the bathing waters that are permanently/temporarily forbidden to bathing, in order to protect the health of bathers, through the affixing, by the Municipalities, of special signs to clearly indicate the delimitation.

For waters prohibited for bathing and for those subject to exceeding the limit values, actions must be taken to improve and manage the waters that safeguard public health and the protection of the water resource (Articles 35 and 36 of the Technical Regulations for the implementation of PTA).

The actions and interventions adopted for each bathing water, which during the bathing season has presented at least once the ban on bathing (YT) and the management measures implemented, at the end of the bathing season must be the subject of reports and communications from part of ARPAM and the Municipalities concerned, which must indicate and specify such information and the DGR indicates the deadlines for sending such documents.

Furthermore, for the purposes of the correct management of bathing water, ARPAM must promptly communicate, to the territorially competent seaside municipality, the analytical outcome of the monitoring for each exceeding of the limit values that occurs during the bathing season, in order to promptly prepare the management documents. necessary (union orders of prohibition and reopening), as well as for immediate communication on the Water Portal of the Ministry of Health.

4.5 Regional rules (Abruzzo Region)

4.5.1 General principles

The Abruzzo Region for water management mainly uses two tools: the Water Protection Plan (2015), currently being updated, as a tool for the classification of surface and groundwater; and the Coastal Defense Plan from Erosion, the Effects of Climate Change and Pollution (2021) as a related system for managing pressures and responses relating to coastal waters.

The Water Protection Plan (PTA) of the Abruzzo Region adopted with the DGR of 16 December 2015, represents the technical and programmatic tool through which the qualitative and quantitative protection objectives provided for by art. 121 of Legislative Decree 152/06.

It constitutes a specific sector plan and is structured according to the contents listed in the aforementioned article, as well as according to the specifications indicated in part B of Annex 4 to the third part of the Legislative Decree itself which provide for:

• general description of the characteristics of the catchment area for both surface and groundwater with cartographic representation,

• summary of the pressures and significant impacts exerted by anthropogenic activity on the state of surface and groundwater,

• list and cartographic representation of sensitive and vulnerable areas,

• map of the monitoring networks established pursuant to art. 120 and annex 1 to the third part of the aforementioned decree and their cartographic representation,

• list of quality objectives,

• summary of the programs of measures adopted,

• summary of the results of the economic analysis,

• summary of the integrated analysis of the various factors that contribute to determining the environmental quality status of water bodies,

• report on any further programs or more detailed plans adopted for certain sub-basins.

The Plan allows the region to classify surface and groundwater and establishes the objectives and intervention measures for the requalification of classified surface and groundwater.

The priority objectives of the PTA of the Abruzzo Region are, for the qualitative protection of surface and groundwater, the achievement of the environmental quality status corresponding to "good", while, for the quantitative protection of surface and groundwater, the elimination of the deficit water on the groundwater and the maintenance in the riverbed of a minimum vital flow.

An IT support, commonly known as Geographic Information System, was created and developed for the acquisition and management of the data that help to outline the Knowledge Framework of the Water Protection Plan.

The Abruzzo Region with the DGR 32/2020, DGR 526/2020 and DGR 658 / C / 2021 has definitively approved the Coastal Defense Plan from Erosion, the effects of climate change and Pollution.

The Tool, addressing the issues of the sector, recognizes and integrates the surrounding conditions relating to mitigation and adaptation to climate change, pollution of coastal marine waters and activities related to coastal defense interventions. bathing.

The Plan has general, direct and indirect objectives, which in the formulation and overall implementation guarantee the achievement of the objectives of protection and development of the coastal system by maintaining the conditions of physical stability, the naturalistic values present and that part of the economy strictly connected to the riparian territories.

In particular, the general objectives are:

1. defense of beaches and coasts from erosion, climate change and pollution;
2. protection of the quality of marine waters, ecosystems and bathing waters;
3. sustainable and efficient management of the resources of the Abruzzo coastal system, identifying economies of scale also through innovative interventions;
4. effective technical and administrative action in coastal protection actions;
5. promote knowledge of analytical and intervention techniques;
6. promote the conservation of protected areas and those of high naturalistic, environmental and cultural value;
7. participate in national policies and plans and community experiences.

4.5.2 Specific goals

The Abruzzo Region in the specific field of bathing water quality and in particular the governance of the procedures connected to it has developed over the years some guidelines through the issue of DGR aimed at guaranteeing greater effectiveness in the application of national regulations and to the participatory and involvement processes of the Abruzzo community.

The DGR n.301 of 21.04.2015 established the Regional Council and the Technical Table which are two bodies that have the function of involving the institutions of the authorization and monitoring procedure with stakeholders on the issue of bathing. In particular, the Technical Roundtable has the institutional task of deepening the data of the planned monitoring, evaluating and forecasting scenarios and identifying remedial activities in the event of specific critical issues related to the integration of water quality with the activity of bathing. The issue of involvement makes it possible to sensitize operators in the tourism-hospitality sector on the urban issue of wastewater management.

The criticality connected to the theme of the Pescara river, seat of the Pilot site, made it necessary to set up a specific task force, with the DGR n. 606 of 23/10/2019, with the aim of monitoring and dealing with the complex issue of the management of the port infrastructure, the progress of the important interventions financed on the purification system that it confers on the river itself and on the tourist-accommodation economic theme linked to bathing of the city of Pescara. An important issue addressed was the so-called opening of the breakwater to protect the canal port which made it possible to record important changes in river dynamics and the flow of water in the stretch of sea facing it.

The annual management of bathing in Abruzzo, in compliance with Legislative Decree 03/04/2008, n. 116 and to the Ministerial Decree 30/03/2010, in the year 2021 it was guaranteed with the issue of DGR no. 241 of 3.05.2021 which, following the monitoring of the waters during the 2020 bathing season, assessed and classified the waters over the four-year period 2017-2020, assigning the values and defining the prohibitions.

The Water Protection Plan deals with the data of bathing waters, the monitoring of coastal marine waters, which is carried out annually with the reading of the quality of surface water bodies, and also the control and communication relating to waste water discharges.

With DGR 468 of 12.07.2016 - Regional Law 3 November 2015, n. 36, art. 6 - the PTA governs the provisional authorization of urban waste water discharges in implementation of art. 124 paragraph 6 of Legislative Decree 152/06 and subsequent amendments.

The new Coast Defense Plan addresses the issue of pollution and therefore the quality of coastal waters, in particular with general objective 2.

Within the general direct and indirect objectives, a series of mission objectives are defined and explained that describe the actions that the plan proposes to pursue. In particular, with reference to the protection of the quality of marine waters, ecosystems and bathing waters, the following sub-objectives exist:

- resolve the interference between rainwater discharges and beaches;
- limit the effects induced on the quality of bathing water by structures and transitional waters (mouths of rivers);
- evaluate the effects of current coastal defense schemes.

It is important to underline that the structure of the plan among its regimes provides for specific interventions in order to improve bathing water also through innovative systems. The theme of the relationship between defense structures, water exchange and rainwater transfers determines the proposition of intervention scenarios of which the Pescara river is also located in its outlet into the sea and in particular in the northern part which is particularly affected by the influence of water quality combined with the presence of coastal defense works. The Plan provides in its technical regulations (NTC) both in the construction phase of new works (Article 23 NTC) and in the maintenance (Article 24 NTC) of existing ones, the assessment of compatibility in relation to the quality of bathing water and interference with coastal hydrodynamics. The Plan prohibits, in the stretches of coast characterized by poor quality of bathing water, Article 8 of the II Legislative Decree 116/2008, the construction of emerged works in the event of the presence of rainwater drainage channels into the sea, subordinating the construction through the removal of the canals beyond the barriers and only following verification of the adequacy of the water exchange in the short and long term.

Finally, the Abruzzo Region financed through the resources of the Masterplan, with DGR n. 229 of 19 April 2016, the implementation of the Port Regulatory Plan of the Port of Pescara which provides, among other things, the diversion of the entrance with the removal beyond the current breakwater of the mouth, in order to secure the port structure , minimize the tendency to silting up the same, move the river waters away from the coast. Also within the framework of the Masterplan, important interventions were financed to upgrade the purifier, the collection of rainwater to the same through the construction of a first rain tank.

4.6 Regional rules (Croatia - Split-Dalmatia County, Dubrovnik-Neretva County, Istria County)

4.6.1 General principles

Regional rules for inland waters are comprised of previously mentioned national regulations. Hence, according to the OG 51/14, the local public authorities are in charge of:

- determination of bathing locations and monitoring of bathing waters in their jurisdiction,

- encouraging public participation in activities concerning bathing water quality assessment of the bathing locations and bathing season,
- informing the public on bathing water information during the bathing season.

Moreover, they are obliged to deliver bathing water quality and monitoring assessment to the Croatian Waters for each bathing water, in their jurisdiction, annually after the bathing season is over.

Regarding sea bathing water quality (OG 73/08), the regional public authorities are responsible for granting concessions on the public beaches or the concessionaires themselves. In the latter case, the regional public authorities are responsible for maintenance, monitoring and regular sampling of the bathing seawater on the beaches as well as proper marking of the beach. The concessionaire of the beach and/or local public authority is obliged to display information boards on sea beaches referred to in Article 7 of Regulation OG 73/08 with information on seawater quality, general description of the sea bathing water, sea bathing water profile and information on possible emergencies on the sea beaches. The *National report on annual and final seawater quality assessment on the beaches of the Croatian Adriatic Sea* provides an insight into county reports including Split-Dalmatia County (SDC), Dubrovnik-Neretva County (DNC) and Istria County (IC). Moreover, *Regional programmes for the organization and management of sea beaches* have been developed in all Adriatic counties at the initiative of the Ministry of Tourism. The aim of their development is to strengthen the competitiveness of Croatian tourist destinations, and especially to establish a systematic, thoughtful and sustainable approach to the organization and management of sea beaches.

4.6.2 Specific goals

When going into detail, each aforementioned county determines the number of monitoring points for seawater quality testing, the number of testing performed and annual/final water quality assessment. The testing is performed by a responsible public health institute within each county.

The protection of waters and seawater on the county level (SDC, DNC, IC) is comprised of the environmental protection programmes for each county. Within each program the pressures and drivers and related specific objectives and measures to protect and preserve the sea and maritime environment and sea bathing water quality are described.

Related to the protection of waters and the aquatic environment is the efficiency of utility infrastructure. That refers to county water protection plans. Such plans refer to water supply and drainage systems, i.e., optimization of road transport, (re)construction of pipelines, channels and collectors, upgrade of the wastewater treatment plant to a higher level of treatment and expansion of the wastewater drainage network to increase the number of people connected to it. The plans result in conclusions and recommendations for the infrastructure upgrade and suggestions for the further development of the water supply and drainage system. For example, one of the measures of the *Dubrovnik-Neretva County* e*nvironmental protection programme* is the construction and upgrade of the public wastewater drainage system while the *Istria County* e*nvironmental protection programme* contains measures on re(construction) of submarine discharge pipelines and upgrade of level of treatment. The Split-Dalmatia County included seawater quality and aquatic environment protection in its *Split-Dalmatia County tourism development master plan (2017 - 2027) with strategic and operational marketing plans* consisting of programs for the improvement of utility infrastructure.

4.7 Correlation between the rules and integration with WATERCARE Project

The previous paragraphs described in detail what are the fundamental principles on which the regulations currently in force at the various levels (Community, national and regional) are based and which, consequently, are the objectives towards which this regulatory apparatus is addressed.

It is pleonastic to write that the Italian national legislation can differ from the Croatian one, just as the different regional regulations can follow the peculiarities that each territory inevitably brings with it. However, it should not be forgotten that all the regulations issued must refer to Community law and must not depart from it except to better define the practical actions to be undertaken to achieve the EC objectives.

In fact, the philosophy of the European community has an interdisciplinary approach and its purpose is to protect the ENTIRE water body: this is evident, as it is foreseen both by the

Framework Directive on Water (2000/60/EC) and by the Directive relating to the Management of Bathing Waters (2006/7/EC), which provides for a control and management system for the quality of these waters, based on monitoring and prevention.

The transposition of the EU directive in Italy took place in 2008, with Legislative Decree no. 116, which will be followed by the implementing ministerial decrees of 30 March 2010 and 19 April 2018. The aforementioned EU interdisciplinary approach finds its concretization in these Italian regulations, integrating various innovative tools, some of which already present in the EU directive concerning bathing, such as bathing profiles, the forecast of short-term pollution, the classification of bathing water into four quality categories, the role of public participation, information to bathers in real time and water monitoring.

With regard to the management of bathing water quality, as already underlined above, with respect to the Community law, the Italian decree 116 of 2008 defines the division of competences between the State, Regions and Municipalities, investing the latter with the obligation to delimit prohibited areas to bathing, should they find themselves in non-compliance conditions, due to exceeding the limit values of the microbiological parameters, which were defined only with the implementing decree of 2010.

Finally, we remind you that, on a national level, in Italy, the dictates of the Community law find their fulfillment also in the definition of the information useful for composing the profile of each bathing water, as illustrated in the ministerial decree of 2010.

But the various regulatory levels, to be effective, must have a correspondence with the rules that govern the management of bathing water at the regional level.

4.7.1 ITALY - Marche Region

In Marche Region, whose territory has a very strong tourist vocation also and to a large extent from the marine point of view, a Water Protection Plan is in force, which identifies the marine-coastal waters of the entire coast as significant water bodies. , to be preserved from the negative impacts generated above all by urban wastewater discharges.

Defining the authorization conditions and the precautionary limits of such discharges also means protecting bathing, not only from an environmental point of view, but also and in the first place from a health point of view.

Here then the PTA, in its Technical Implementation Standards, clarifies the best practices for creating separate sewers (urban wastewater and rainwater), first rain tanks (article 43), flood spillways (article 36) , wastewater treatment plants and infrastructural interventions (article 35).

Since bathing waters (BW) represent waters with a specific purpose, the protection of which must pursue the objectives indicated by the Community directives 2000/60 / EC (water framework directive - DQA or WFD) and 2006/7 / EC (directive on bathing waters - DAB or BWD) and integrate with the objectives of the directive on marine strategy 2008/56 / EC (framework directive on marine waters - MSFD), the resolution of the Regional Council, which annually issues the Marche Region, as well as , as already written, updating the knowledge framework requested by the Management Plans of the Hydrographic Districts and the Water Protection Plan of the Marche Region, implementing the planning of the aforementioned directives, makes concrete the strengthening of the protection of bathers, through the guarantee of compliance of bathing water and the improvement of the quality of the same.

Among the most significant actions is the adoption of the management union orders (OSG) which, as a preventive measure, the Marche Region has been proposing for years to seaside municipalities where there are floods of sewer networks[8].

The OSG activates the bathing ban as soon as the drainage of urban wastewater is active, a condition that generates the situation of high risk of contamination and, for these last two bathing seasons, of spread of the virus.

Based on these considerations, the Municipalities are stimulated to promote the adoption of this union order, in collaboration with the Management Bodies of the Integrated Water Service.

Among these guidelines, already adopted in previous measures, for the 2021 bathing season, further measures aimed at the use of alternative methods are introduced, as required by decision no. C (2017) 5843 of 01/09/2017 of the European Commission relating to the rules

---

[8] *With reference to the current epidemiological situation determined by the spread of COVID-19 and the guidelines that will be issued by the competent health bodies on the measures to contain and/or mitigate the risk of exposure to the virus, both on the beaches and on the bathing waters, the flooding of Urban waste water from sewer networks on the shoreline or directly into bathing waters represents one of the risks of contamination.*

on the equivalence of microbiological methods, in order to reduce the analytical response times and reporting of microbiological analyzes, making the analytical result available within the following 24 hours instead the usual 48 hours. This measure reduces the days of “analytical” closure of the BWs, favoring the right use, while maintaining a high level of health protection.

However, there are critical points where current law does not work best. In fact, once the sample has been taken, the analytical reports are obtained from the laboratory in a minimum period of 24 hours: in this time window, if I preclude the water from bathing only once the results of non-compliance of the water itself have been obtained, I could have water polluted and bathers in the sea. Furthermore, if rainfall is abundant, but no calendar monitoring is foreseen, an eventual overshoot of the microbiological parameters, which leads to non-compliance of the BW, may not be detected.

In light of the foregoing, since the control is performed according to a predetermined schedule, in which few variations are allowed, it is clear that monitoring is not always able to represent the evolution of events.

It would be necessary to close the BWs promptly before obtaining the analytical results of non-compliance, having the suspicion that the urban wastewater discharged into the sea has contaminated the bathing waters.

In particular, in the case of BW on which floods or mouths insist, in the Marche Region, as already mentioned, a form of greater health protection has been passed, using the management union orders (OSG), which make excellent representations of the phenomena that occur in the event of overflows and give the possibility to better manage the closing and reopening of the BWs subjected to it, allowing the maximum hygienic and sanitary protection of bathers.

The initial assumptions to be made are:

1 - what is the typicality and quality of each site (of each BW);

2 - as a result of meteorological events with particular intensity of precipitation, in many BW there is a flood of Urban Waste Water (UWW).

It is therefore necessary to understand HOW MUCH these UWWs overflow and FOR HOW LONG they do so.

The water service managers, where the spillways are equipped with remote control, inform the Municipalities as soon as these artifacts are activated and as soon as they are deactivated (when the rain starts, the spillway is activated and when the meteoric event ends the spillway is deactivated).

With the OSG tool, this mechanism can be managed, avoiding the exposure of bathers to these UWWs (health protection).

However, the European project WATERCARE will have a further development with respect to the management ordinance, as it will allow the development of an Integrated Water Quality System (WQIS), to correlate meteorological events - drainage system response - microbial impact on water bathing. In fact, the model will provide a real-time warning system of the quality of wastewater and its discharge in the sea, as well as of fecal bacterial dispersion in coastal waters.

The modeling system implemented by the WATERCARE project is composed of a meteorological, hydrological and microbiological monitoring network and a numerical model of coastal waters (FOM) to simulate and predict bacterial dispersion in bathing waters.

The monitoring network is based on a meteorological database, which receives real-time data on both rainfall and the level of urban wastewater, evaluating the surface runoff phenomena and considering the time lapse between each rainy event and the previous one; This network will also be accompanied by the data collected from the bacteriological analysis and everything will be stored in a specific monitoring database.

All the records collected will be used to feed a real-time Alert System, which will provide support for the optimal management of the quality of river and coastal waters and will also be able to identify bacterial dispersion, and therefore, critical areas. where bathing should be prohibited.

Furthermore, within the WATERCARE project, in the pilot area of Fano, an accumulation tank was built for the first rain water, whose specific objective is to retain the first waters that fell during the storm, which present the greatest polluting microbiological loads, deriving from the draining runoff at the beginning of the rainy event.

The collected quantity will allow to minimize the impact on the receiving river or on the coastal waters used for bathing, if the meteorological event is quantitatively significant and therefore impossible to contain by the sewage system. This infrastructure will make it possible to verify exactly what is the positive impact of the collection of first rain water in environmental terms and to measure, if it had not been realized, what would have been the quantity of pollutants released into the environment and not adequately treated. from the purification plant.

Therefore, the result achieved will consist in a significant improvement in the quality of bathing water, both because the discharge of the most polluted waste water will be avoided, and because it will allow a better treatment of the collected waste water, once the storm is over.

Finally, the WATERCARE project has enabled the creation of an integrated and intelligent system of decision-making processes to help responsible authorities and stakeholders (operators of tourist facilities and services, swimmers and bathers, etc.) to obtain control of the meteorology, bacterial load and drainage of the sewer system in bathing water.

The project made two essential and innovative aspects concrete:

- an estimate of the microbial contamination associated with the assignment of the environmental status and natural variability (meteorological conditions), currently completely absent in the scenario of governance processes;

- the response to the problem through ad hoc infrastructures and the implementation of a WQIS that correlates the environmental conditions and the impacts generated by the spillage of waste water.

That is, as written above, the understanding of HOW MUCH the Urban Wastewater overflows into the bathing waters and FOR HOW LONG they do so, making it possible for the competent bodies to foresee the closure of the BWs, avoiding in time the health risk to bathers and users of the water resource.

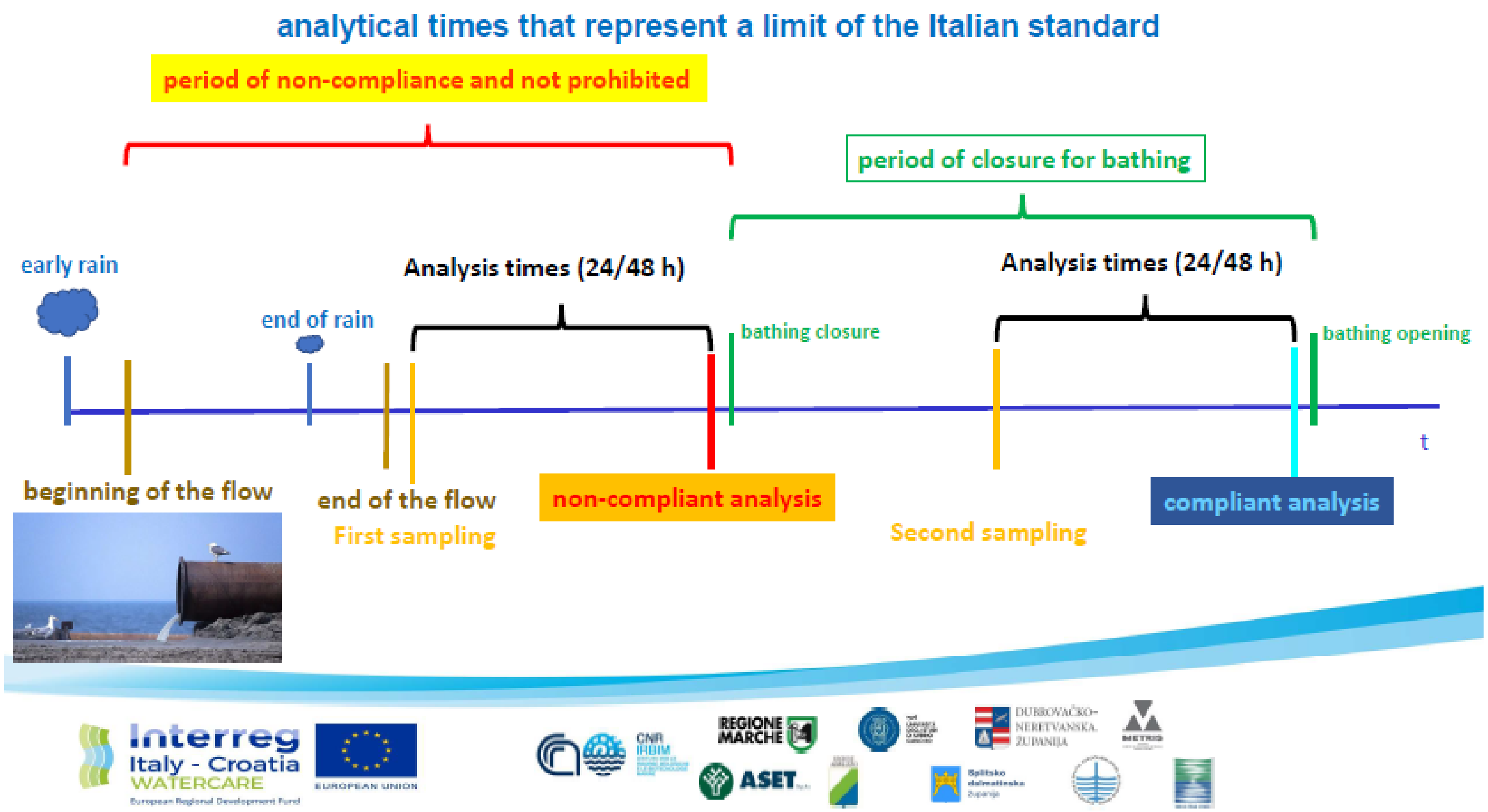


Figure 4.5.1 - 1 BW closing mechanism without management union order.

4.7.2 ITALY - Abruzzo Region

Taking into account the general objectives of the WATERCARE Project, such as:

1. improve the environmental quality conditions of the sea and the coastal area through the use of sustainable and innovative technologies and approaches;

2. reduce the impact of microbiological environmental contamination in bathing water, resulting from abundant rainfall introduced into the local drainage network, with consequent release into the sea;

3. improve the water quality of urban areas and support their governance through a management process in the identified study areas,

and of the system implemented in the Pescara pilot site, the correlation between the fundamental principles on which the regulations reported so far are based and the general objectives of this project are reported below.

The PTA is responsible for evaluating the pressures and significant impacts exerted by anthropogenic activity on the state of surface waters, and also for providing specific mitigation and monitoring measures.

In the case of the section of the Pescara river concerned, where the pilot site falls, improvement interventions are planned for the existing purifier. Furthermore, the criticality of the river waters and its repercussions on the quality of bathing water led to the issuance of authorizations in order to manage the Pescara urban purification plant in Via Raiale, managed by the consortium of the Service Idrico Integrato ACA SpA. The Authorization DPC024 / 062/2018 has in fact defined a specific disinfection, discharge and monitoring procedure ILC33.03, in the event of important meteoric events, pending the adaptation of the purifier.

The objectives of the WATERCARE project are fully taken up by the Coast Defense Plan. In fact, by addressing sector issues, the tool recognizes and integrates, to the instances of coastal defense intervention planning, the surrounding considerations relating to mitigation and adaptation to climate change, pollution of coastal marine waters and bathing related activities, providing for the use of sustainable and innovative technologies and approaches.

As previously reported, the PDC provides in its technical regulations both in the construction phase of new works (Article 23 NTC) and in the maintenance (Article 24 NTC) of existing ones, the assessment of compatibility in relation to the quality of the water bathing and provides for specific measures relating to the drainage channels of rainwater into the sea (Article 31 NTC):

1. the construction of new pipelines or systems for the delivery of rainwater to the sea is prohibited on stretches of coastline whose bathing water quality classification, pursuant to art. 8 and Annex II of the Legislative Decree 30 May 2008, n. 116, from 2015 to 2018, is "poor". In case of presence of longitudinal defense works, during the maintenance of the same, the existing pipelines on stretches of coast classified as poor must be removed offshore;

2. where permitted, the new construction of pipelines or systems for the delivery of rainwater to the sea must be carried out perpendicularly to the coastline;

3. where permitted, it is preferable to build new pipelines or delivery systems to the sea integrated with the defense and transversal works.

With reference to the pilot site, the Coast Defense Plan envisages conservation and enhancement interventions of the coast north of the Pescara river mouth, locally as a targeted transformation, aimed at improving the environmental quality of the water and redeveloping the existing defense system.

The monitoring system implemented for the WATERCARE project, which affects the final stretch of the Pescara river and the area facing the mouth, allows the knowledge of the diffusion of the pollutant and the creation of an Alert System for the pilot site, the achievement of coordination of the objectives foreseen by the instruments of the Abruzzo Region and a correct management of the activities to be carried out.

Finally, the WATERCARE project would allow the creation of a coordinated system between the responsible authorities and the stakeholders for the correct management of the bathing ban.

4.7.3 CROATIA

From regulations, both European and Croatian, it is evident that water is primarily considered as a limited resource that should be protected, preserved and used efficiently. Given that the Republic of Croatia is a member of the European Union, it is understandable that the Croatian legal framework regarding water protection and conservation is based on existing

European one, as stated in the previous chapters. After joining the European Union, the Republic of Croatia continued to transpose European regulations to its national framework. The umbrella law on water issues in Croatia is Water Act (OG 66/19) which has been aligned with all existing EU directives regarding water. This concerns, in particular, the alignment with Directive 2000/60/EC known as the Water Framework Directive (WFD). The WFD adopted a new approach to evaluating water status based on the fact that different water types have different ecological characteristics. For this reason, the typology of surface waters was introduced, the main purpose of which is to define reference conditions specific to certain types of surface waters and is the basis for the classification of the ecological status of waters. This refers to all bathing waters that are defined as protected areas. A high level of protection of bathing waters and contribution to pursuing the objectives of preserving and improving its quality, as well as protecting the latter and the human health reduces the risk of infection and various types of diseases and also reduces environmental pollution. Regarding the increase of efficiency and rationalization of the use of resources, the environmental policy of the Community is especially emphasized, as written in the introduction to the Directive 2006/7/EC concerning the management of the bathing water quality.

Accordingly, Croatia's national legislation is aligned with all European regulations relating to the protection of bathing waters. Hence, provisions on bathing waters are comprised by Water Act (OG 66/19), Regulation on bathing water quality (OG 51/14); Regulation on sea bathing water quality (OG 73/08), Regulation on special conditions for the performance of activities to prevent the spread and eliminate the consequences of extraordinary and sudden pollution of water and water resources (OG 3/20), National Plan of Measures in the Event of Extraordinary and Sudden Water Pollution (OG 5/11) and others. On a regional level, county authorities (SDC, DNC, IC) are able to develop and adopt plans and programmes including bathing waters. Currently, measures to protect and preserve sea bathing water quality are described in counites environmental programmes. Moreover, counties can collect and analyze data about bathing waters, manage them and define possible risks. Also, regional public authorites (for sea bathing water) and municipalities (for inland waters) determine bathing locations, encourage public participation in activities concerning bathing water quality assessment of the bathing locations and bathing season and inform the public on bathing water information during the bathing season. Since the protection of waters and the aquatic environment is closely related to the efficiency of utility infrastructure, counties develop water protection plans. Such plans refer to better management of water supply and drainage systems that result in higher water efficiency, preservation and environmental protection.

With regard to achieving and preserving overall good water status according to the requirements of the WFD, which includes achieving a good ecological status of all surface water bodies (inland, transitional and coastal waters) to maintain a high level of quality, frequent sampling and testing are conducted. Water quality assessment aims to determine the level of deviation of the tested parameters from the natural ones. Given the level of deviation from the reference values, the samples are classified into five different categories of ecological status and are given the corresponding limit values for indicators. Limit values for each category's ecological status of indicators of basic physicochemical and chemical quality elements are prescribed by the Regulation on the water quality standard (OG 96/19).

Considering that the goal of the WATERCARE project is to improve the quality of microbial, ecological and resource efficiency in transitional and coastal bathing waters, the laws of the Republic of Croatia in this regard are set in the right direction. Moreover, The Government of Croatia has adopted the River Basin Management Plan for the period from 2016 to 2021. The plan consists of several parts that seek to present the human impact on water status and program of measures to mitigate those impacts, protect human health and achieve a good environmental status of waters.

This principle can be related to the establishment of a system for monitoring and improving the conservation of bathing waters within the WATERCARE project. Accordingly, the Republic of Croatia procured, installed and tested the Water Quality Integrated System (WQIS) in three pilot areas (rivers Rasa, Cetina and Neretva) covered by the project. WQIS enables timely monitoring and control of water quality. It consists of a real-time hydrometeorological monitoring network and a Forecast Operational Model (FOM) for the determination of the correlation of meteorological events and reactions in the public drainage system (rainwater overflow) about the presence of faecal bacteria in sea bathing water.

The implementation of a real-time alert system that can early identify the fecal pollution of sea bathing water will enable timely reaction and remediation of pollution promptly. This can be specifically important during the summer season considering Croatia is a tourist country with a big influx of tourists in the summer months. Due to that fact, the load on the existing water and drainage infrastructure is also increased. Consequently, this represents a great risk of bathing water pollution as the water is discharged directly into the sea.

Moreover, Croatia's nautical tourism is one of the most important branches of the tourism and its nautical fleet, with over 4,500 charter vessels, is the largest in the world. Even though, Croatia has regulations on collection wastewater from vessels (eg. Rules for statutory certification of maritime vessels, pollution prevention (OG 8/20) and Ordinance on vessels, boats and yachts (OG 13/20)) wastewater is most commonly discharged directly into the sea at any location including areas of bathing waters. Hence, causing their pollution. Therefore, it is necessary to increase the number of monitoring stations and the frequency of bathing water sampling to have better and timely insight on pollution occurrence and consequently determine whether seawater is suitable for bathing. This is where the WQIS can be of great help.

The WATERCARE project also envisages the collection of data on bathing water quality along the entire Croatian coast and their analysis to determine the impact of precipitation on bathing water quality in the area. These data, combined with data on human impact on bathing water quality, give a bigger picture of the direction in which water protection and prevention measures should go. This way, due to information collected with WQIS, the Croatian and Italian sides of the Adriatic will reduce the risks of negative human and natural impacts on bathing water quality.

To conclude, the problem of bathing water pollution is not only Croatian or Italian, it is a problem that the whole of EU is facing. For this reason, the WATERCARE project will seek to link the entire process of monitoring, analyzing and improving methodologies for water quality conservation between the countries and as such will be of great benefit to local authorities.

4.8 Figures index

5. COGNITIVE FRAME

5.1 Description of conceptual methodology and pressures (and impacts)[9]

The methodology and approach used in the Watercare project follow the DPSIR model, adopted by the European Environment Agency.

The DPSIR model (Driving forces, Pressure, State, Impact and Response) proposes an integrated approach on the state of the environment, at every level, be it European or national: in fact, it represents the set of elements and relationships that characterize any environmental issue or phenomenon, relating it to the set of policies exercised towards it.

The model is schematized in subsets, linked together by a chain of causal relationships. In particular:

D - Driving forces: human activities and behaviours deriving from individual, social, economic needs; lifestyles, economic, production and consumption processes that give rise to pressures on the environment;

P - Pressures: exerted on the environment as a function of the determinants, that is, of human activities and behaviours such as atmospheric emissions, noise, electromagnetic fields, waste production, industrial waste;

S - State: qualities and characteristics of the environment and environmental resources that can be challenged by pressures, qualities considered as values (physical, chemical, biological, naturalistic, testimonial, economic) that must be protected and defended;

I - Impacts: significant changes in the state of the environment that manifest themselves as alterations in ecosystems, in their ability to support life, human health, social and economic performance;

---

[9] http://sira.arpat.toscana.it/sira/sira/dpsir.html

https://www.snpambiente.it/2016/12/07/la-rappresentazione-delle-componenti-ambientali-il-modello-dpsir-e-gli-indicatori/

https://www.eea.europa.eu/help/glossary/eea-glossary/dpsir

L. Bolognini, Marche Region: "*Bathing waters: the potential risks for urban wastewater management in consideration of the effects of climate change*", 6th annual Forum EUSAIR, 10/05/2021

R - Responses: government actions implemented to face the pressures; the object of the response can be a determinant, a pressure, a state, an impact, but also a previous response to be corrected; the responses can take the form of objectives, programs, financing plans, interventions, etc.

In addition to the aspects concerning the determining forces and the pressures present on the water bodies, the other aspect to consider is that relating to the state of the same, that is the one concerning the quality of the water body receiving the floods and the type of use, which determines the greater or lesser fragility, especially when referring to microbiological contamination.

With particular reference to the problem faced within the Watercare project, the determining forces and pressures exerted on surface water bodies and bathing waters are analysed below, subdividing the conditions that determine occasional and continuous criticalities: the former are due to occasional inputs that are limited in time, while the latter are due to contributions and contributions that have greater continuity over time.

5.1.1 Occasional criticalities

5.1.1.1 Climate change and atmospheric events

In the last decade, the climate changes we are witnessing are increasingly the cause of atmospheric events of considerable intensity. In addition, long periods of drought alternate with periods with high intensity rainfall.

The problems arising from these changes concern, from the hydraulic point of view, not only natural water bodies (hydrogeological risk), but also sewer infrastructures. In fact, with reference to minor surface water bodies, there are increasingly frequent phenomena of flooding, both in agricultural areas and in urban areas and road infrastructures (in particular, in the event that it is not possible to guarantee effective drainage of surface washout).

With reference to the sewage infrastructures, serving urbanized areas with mainly waterproofed surfaces, they are forced to receive, in a very short time, large quantities of water, a phenomenon that soon leads to the activation of the wastewater drainage systems.

5.1.1.2 Infrastructure breakdowns

Although the sewage infrastructures are designed to contain volumes up to four times the value of the ordinary flows, during the meteoric events mentioned above, due to the nature and intensity of these ones, we arrive in a short time to the overflow of urban wastewater in surface water bodies or directly in the sea, if not, even, to the breakdown of the infrastructure itself: to avoid this situation, appropriate drainage structures are created.

5.1.2 Continuous criticalities

The system drainage and by-pass systems have therefore become increasingly essential and indispensable for the structural maintenance of the systems and installations connected to them and cannot be eliminated.

The factors that determine the quality of the discharged water are, mainly, the intensity of the event, the size of the area served and the number of residents and tourists connected, which are the cause of the contribution of polluting loads into the sewer system.

We can identify the most significant contributions on bathing water by dividing the contributions according to their origin, or according to whether they are determined by drainage ditches, mouths of rivers or streams and direct discharges.

5.1.2.1 Drainage ditches (natural and artificial)

Along the coastal strip there are several natural or artificial drainage ditches, which allow the drainage of rural areas around urban centers and / or areas with a prevalent agricultural character. In these drains can be identified / planned outlets of sewer networks

As part of the construction of sewage systems, even quite extensive, aimed at collecting all possible discharges produced by civil dwellings or by service or production activities belonging to hamlets with a small number of inhabitants, the networks normally collect, along their path, both wastewater of various kinds, and drainage water from the areas serving the settlements themselves.

The drained areas are, in these cases, relatively contained, therefore, during meteoric events, even the drainage waters can have a very low volume.

Since 2010 (the year in which the Water Protection Plan was approved in the Marche Region), new urban developments must provide for the separation between rainwater and wastewater.

The drainage ditches, therefore, unlike the mouths of rivers and streams, are almost always dry, except in case of rain: there is, in principle, the presence of water only during meteoric events and receive contributions from the floods of the sewer networks and, after 2010 by virtue of the guidelines given by the Water Protection Plan of the Marche Region, also from the drainage water of the waterproofed areas of the settlements mentioned above.

5.1.2.2 Rivers and streams mouths

Unlike what is written in the previous paragraph for the drainage ditches, the rivers and streams that flow into the bathing waters also receive contributions from areas that are not located along the coastal strip, but are more inland.

In these streams and rivers the water flows perpetually and, in addition to being already subject to the drains of the sewage structures (directly from the overflows of the sewer lines that run parallel to the watercourse itself), they too, during meteoric events, they undergo the contribution of the minor hydrographic networks, receiving the hydraulic load.

In addition, always during the rains, they also suffer the possible load of the larger networks of the large agglomerations, as well as the by-passes of the purification plants.

5.1.2.3 Direct discharges (ARD, ARU and ARI)

Direct discharges of domestic wastewater from residential settlements, urban wastewater from urbanized areas and industrial wastewater, along the coastal strip and into bathing water, is occasional, as direct discharges are rarely granted into marine waters in the Marche Region , especially if these discharges directly impact bathing water.

In fact, in Marche Region it is consolidated the fact that it is always preferable to grant authorization for discharge into the water bodies referred to in the two previous paragraphs, that is, in the terminal sections of rivers and / or streams or in drainage ditches, with very modest loads.

This is because, by allowing discharge into internal surface water bodies, a lower direct impact can be guaranteed (discharging into a river with running water has a lower impact than direct discharge into bathing water).

Furthermore, no bathing water is identified in the area of diffusion of the river plume (which is generated from the mouth), since critical conditions may arise due to possible contributions of microbiological loads.

There are, therefore, different **impacts** depending on the water body affected by the pressures described above. For example, a river that has substantial flows, due to meteoric events, is a system with low fragility, since both the large volumes and the strong flow of water do not favor the spread of microbiological contamination. On the other hand, a bathing water protected by cliffs represents a very fragile system, since the scarce flow in the horizontal direction and the scarce mixing in the vertical direction of the water do not allow a rapid decay of the bacterial load possibly present in it.

With reference to the possible responses in the management of bathing water and in the construction of infrastructural works, aimed at containing the floods of urban wastewater, the WATERCARE project has provided concrete indications.

There are mainly three different types of intervention to be adopted:

1. reduce the quantity of drainage water in the sewer networks;

2. drain these drainage waters directly into water bodies, which show reduced fragility;

3. retain the sewer water from the first rain and allow the subsequent ones to flow, which flow after the first washout of the sewer networks.

In the first case, the reduction in the amount of water fed to the sewer networks allows for lower hydraulic loads, which reach the system without causing overflows or, in any case, significantly reducing overflow events.

In the second case, if the served area produces significant hydraulic loads with significant polluting loads, the wastewater can be drained in sites or water bodies that can withstand the impact, both in qualitative terms (these receiving bodies must have guaranteed the capacity diffusion and mixing without confinements), and in quantitative terms (the receptor bodies must be able to sustain important and frequent floods).

In the third case, the strategy adopted is to contain, in accumulation tanks, the first rain water, i.e. the initial volume of flood water, which, notoriously, is the most polluted, because it also collects the material that usually settles during the ordinary operation of the infrastructure and which, when it rains, not only is the first to be washed away, but is also endowed with a very concentrated polluting charge. In some situations, therefore, the effective solution can be constituted by the construction of rainwater accumulation tanks discharged from the networks in the first periods, to be sized according to the structure of the sewer networks themselves.

These last interventions in urbanized areas are very difficult to carry out, because the first rain tanks must have a considerable capacity; consequently, the volumes required for the tanks themselves and for the services connected to them imply the occupation of rather large areas.

5.2 Site-specific assessment

The impacts that discharges have on bathing water are strongly conditioned by a series of characteristics specific to each bathing site: these aspects are the same that must be defined to characterize the predictive model of critical scenarios.

Referring to the Italian Adriatic coastal strip, especially to the bathing areas with low beaches, one of the aspects to consider is that relating to the stationary and forcing currents, as the contributions deriving from the mouths of rivers and streams and from the drainage ditches are influenced by stationary currents, which give direction to the spread of the plume.

At times, then, strong wind conditions can be created (above 10 - 12 knots) which determine forcing, such as to be able to direct the surface currents.

Let's take for example a possible case that occurs in the summer period. A river plume, once it flows into the sea, heads south in the morning, in the presence of a stationary current with a NW - SE direction. During the day, if fronts of more unstable and colder air are created and the forcing increases, the surface currents with the sirocco make the plume change direction, bringing it back to the north (deviation of the plume between stationary and forcing current).

Stationary currents or forcing currents can also cause significant changes during the day. In conditions of daily breeze (from 4 to 8 - 10 knots) the steady currents are favored more, while in the summer night there is an inversion, with the night breezes that have direction from the land to the sea and therefore favor the currents that are away from the shoreline.

The other aspect that affects the impacts that discharges have on bathing water is that relating to the depth of the seabed: a deeper seabed favors situations of mixing of the waters. The most significant mixing is also facilitated by the formation of a thermal gradient in the bathing water (hot water on the surface and cold water deeper).

Compared to Italian beaches, in Croatia, with reference to the impact that waste water has on bathing water, mixing and diffusion are much more evident and effective and this is a fundamental condition, which facilitates compliant analytical results on samples. taken in Croatian bathing waters.

With reference, moreover, to the chemical-physical characteristics of bathing marine waters, it is necessary to highlight how the more salty the waters are, the more the microbiological growth is inhibited.

In stationary waters (i.e. with extremely reduced or even absent mixing), in which a stratification of fresh water and salt water is observed, phenomena of maintenance of the microbiological component could be facilitated, since in fresh waters the microbiological load is more maintained.

Highlighting again the importance of the mixing of water in the abatement of the microbiological load present in the sexes, it is emphasized how this mixing can be modified and reduced, up to being extremely limited, by coastal defense works.

These artifacts, necessary to prevent coastal erosion, must be designed in such a way as to also favor the mixing mentioned above.

In Italy, along the Adriatic coast, in addition to non-confined bathing waters, there are other semi-confined (by groynes or port works of various nature and conformation) and confined (cliffs parallel to the coast line). This does not happen on the Croatian side of the Adriatic Sea, where there are no needs for coastal protection (therefore there are no defense works). If, however, the need arises to safeguard coastal stretches in erosion, they too will have to take into account the need not to inhibit the mixing of seawater.

Another fundamental element for the site-specific assessment is the analysis of the degree of urbanization of the coastal strip.

In fact, the waterproofing of the territory allows the drainage of the water drained into the sea through drainage ditches or streams that cross urbanized areas in a relatively short time. In rural areas (or not heavily cemented) the waters have longer corrosion times, with reference to the inflow into major water bodies and, consequently, to marine waters.

In the event of meteoric events, the contributions from waterproofed areas are more consistent and more immediate than those from rural areas.

5.3 Watercare project pilot sites and their characterization

The five pilot sites studied by the Watercare project are described in the following paragraphs. Two of them are located in Italy and three in Croatia.

Each paragraph contains the minimum information regarding:

- the organization of the site in question;
- the problems that the hydrographic basin of the watercourse in question causes to bathing waters, into which this watercourse is thrown;
- the results obtained thanks to the Watercare project;
- the consequent solutions adopted to mitigate or even eliminate negative impacts;
- the effects that can already be experienced immediately.

5.3.1 Arzilla Site (ITALY)

Arzilla Stream is a watercourse, which measures about 20 linear km from the source to the mouth. It originates from the high-hilly area near Montegaudio (Municipality of Monteciccardo) and flows into the Adriatic Sea on the north-western outskirts of the Municipality of Fano; flows in the municipalities of Monteciccardo, Mombaroccio, Pesaro and Fano. Its hydrographic basin has an extension of about 105 sq km: the reliefs from which it collects water range from about 500 m towards the sources to 100-200 m of the coastal hills. The Arzilla is a torrential watercourse with always active outflow.

With reference to the pressures to which this stream is subjected along its course, we find, from the source to the mouth:

1. the Villa Betti treatment plant, in the Municipality of Monteciccardo, with a capacity of 1000 equivalent inhabitants;

2. the treatment plant of Santa Maria dell'Arzilla, in the Municipality of Pesaro, with a capacity of 1000 equivalent inhabitants;

3. the Candelara and Novilara purifiers, both in the Municipality of Pesaro and both with a capacity of 1000 PE, which discharge sites on the left bank of the Arzilla into minor ditches and, consequently, pour into it;

4. in the stretch that flows in the Municipality of Fano, overflow and / or overflow spillways serving the public sewer system relating to the Ponte Metauro treatment plant:

a. n. 51 - via Goito;

b. n. 1 - Trave overflow;

c. n. 5 - Arzilla overflow;

d. n. 4 - Ex Cif overflow;

e. n. 6 - via del Moletto.

In the event of intense precipitation, the total amount of rainwater runoff and wastewater coming from the entire hydrographic basin determine a direct negative pressure on the surface water course (the Arzilla itself) and indirect on the corresponding bathing waters, facing the mouth of the torrent in question.

On the occasion of these events, the Fano sewerage system, mainly of the mixed type, is hydraulically overloaded and very easily gives rise to floods, with fairly important loads introduced, since the part of the territory served is quite substantial.

As proof of what has just been said, in the last bathing seasons it emerged that, in the presence of particularly intense meteoric events, in conjunction with particular marine weather conditions, the spillage of untreated wastewater, coming from both floods located along the Arzilla stream , both from the addition of rainwater runoff and other wastewater from the entire hydrographic basin, has had an extremely negative impact not only on the bathing water corresponding to the mouth of the Arzilla stream (identified with code IT011041013005 and called "30 meters north Torrente Arzilla "), but also a stretch, equal to about 100 meters, of the adjacent bathing water immediately to the north (identified with code IT011041013032 and called" Arzilla via della Baia ").

All these inputs can cause, even frequently, exceeding the limit values of the microbiological parameters, making the two bathing waters mentioned above unsuitable for bathing; both of these BWs, however, are managed with the Trade Union Ordinance, which, when the spillways are opened, allows the precautionary closure of the waters, which are reopened only after compliant results of chemical, physical and microbiological analyzes, carried out on additional samples, taken by ARPAM at the end of the meteoric event that caused the flood.

As part of the European Watercare project, ASET SpA, managing body of the integrated water service, as well as partner of the project itself, has created an accumulation tank (near the mouth of the Arzilla stream and on its hydrographic left), in which collected the first rain water coming from the sewer system of the Gimarra district and via del Moletto, which will later be conveyed to the treatment plant.

Following this construction, the pollution at the mouth of the Arzilla and the bathing waters in front of it was reduced, mitigating a limited portion, however, of the hydrographic basin. As written above, in fact, the latter, in its overall extension, laps and crosses more municipalities, therefore the tank, alone, cannot produce effects on such a large territory, nor can it in any way mitigate the consequences of the spillage of the waters. coming from upstream, which may consist of flows of rainwater from run-off mixed with waste water and discharges that are not purified or not recorded, or consisting of urban waste water leaks from further authorized artifacts, built to safeguard the public sewer system and located along the entire course of the stream.

It should be noted that the flood spillways of via del Moletto, already mentioned, and of "Arzilla Bath", built from scratch with the construction of the tank, will discharge their wastewater into the same stream only when the maximum capacity level of the tank is reached. first rain, equal to 1600 cubic meters.

As a demonstration and support of what has just been written, with reference to the meteoric events that occurred this year in the second half of August, there was a rainy phenomenon of considerable intensity, following a period of severe drought. The significant amount of rain, which fell in a very short period of time, favored that considerable volumes of rainwater flow into the Arzilla, a situation never recorded in the previous 2 years of monitoring. As a result of this particular meteorological condition, the first rain tank, which contained the drainage of the waste water from the sewerage system, alone could not solve the problems of microbiological contamination, also due to the transport of a very high organic load, coming from from the surrounding areas and within the entire Arzilla hydrological basin, areas that are not drained into the sewage system served by the new tank. The microbial load upstream of the mouth has created a significant negative microbiological impact both on the waters of the Arzilla stream and on the bathing waters facing it.

In this project, the comparison of the data of the pluviometric station, installed near the mouth of the Arzilla stream, with the microbiological data determined along the shaft of the Arzilla stream near the mouth, before being introduced into the bathing sea waters, made it possible to correlate the measurement of a quantity of rain greater than 2 mm, in about half an hour, the presence of a microbial load in the waters of the stream, potentially capable of producing an impact and the relative contamination of the bathing waters overlooking the mouth of the Arzilla.

Therefore, as a consequence of the results obtained from the monitoring carried out and the construction of the first rain tank, the Municipality of Fano considered it appropriate to modify the Management Union Ordinance, defining, for the two bathing waters overlooking the mouth of the Arzilla stream, a new procedure for the protection of bathers, according to which these BWs are prohibited from bathing, when the meteorological station, installed at the mouth of the stream as part of the Watercare project, detects a quantity of rain greater than 2 mm over the period of half an hour.

5.3.2 Pescara Site (ITALY)

The Aterno-Pescara river is the longest river present in the Abruzzo Region, as well as the largest in terms of basin extension (3190 km²) among those that flow into the Adriatic south of the Rhine.

It was born as Aterno on the Monti dell'Alto Aterno, near Montereale, developing mainly between the province of L'Aquila and that of Pescara and minimally touching the province of Chieti; near Popoli it joins the Pescara river.

The Pescara river, the main river of Abruzzo, has a length of 67 km and flows into the Adriatic Sea at Pescara, after having crossed the whole Val Pescara and received various tributaries from the internal valleys (Aterno, Tirino, Orta, Lavino).

The average flow rate at the mouth of the river is about 57 m3 / s.

The Port of Pescara includes the two docks on the river, where the project in question is located, and two commercial docks built in the eastern dock.

The construction of the breakwater in front of the river mouth, completed in 2005, poses various problems to the port, hindering the normal flow of river waters, which are pushed to the north section and lead to the imposition of bathing bans, and creates important accumulations that they contribute significantly to the silting up of the port basin itself and to the modification of the coastal ecosystem.

For this reason, the breakwater was opened in 2018.

With reference to the pressures, upstream of the stretch in question we find the Pescara purifier in Via Raiale / Fosso Cavone, at a distance of about 6 km from the port entrance.

The sewage system afferent to the Pescara purifier is characterized by the presence of some backbones through which the sewage flows to the purifier by means of a series of lifting systems:

• 20 North floodplain;

• 35 South floodplain.

In the event of intense rainfall, the use of first rain basins located in the Città della Musica area is envisaged, to cope with the increases in flow rate, which arrive in the sewer network connected to the purifier.

In conjunction with rain events, the spillage of untreated wastewater, coming both from flood spillways located along the river, and from flows of run-off rainwater and other wastewater from the entire catchment area, has an extremely negative effect the quality of bathing water, both at the mouth of the Pescara river, and in the northern section affected by the presence of bathing establishments.

This entails the imposition of a ban on bathing for the entire stretch. The elimination of this prohibition takes place following the analyzes required by ARTA Abruzzo, the Regional Agency for the protection of the environment, established and foreseen following each rain event.

5.3.3 Raša Site (CROATIA)

The river Raša is 23 km long located in the eastern part of Istria County. The river basin covers an area of 279 km², whereas the estimated hydrogeological drainage area covers 450 sq km. Under the name Raša it appears from the junction of the source streams Karbun and Posert near the settlement of Potpićan. It flows through the Raša valley into the Raša bay, southwest of the City of Labin. The bay is 12 km long and up to 1 km wide. The depth of the bay varies from 44 m at the entrance to the bay to 10 m near the port of Bršica, further towards the mouth, shoals with depths of less than 3 m continue. With its deposits, Raša gradually fills the bay, which is especially noticeable along the west coast. From the overflow of the Rakonek spring to the mouth it is under the influence of the sea and it shows salinity-dependent salinization to a greater or lesser extent depending on the sea tides. During the rainy periods, the flow increases significantly, because the middle part of the stream receives water from several abundant permanent sources (Bolobani, Sveti Anton, Šumber, Grdak, Rakonek, Mutvica, Kokoti, and Fonte Gaja), occasional larger springs (Sušnica, Sušak) and several small unnamed occasional sources.

Referring to the other pressures to which the stream is subjected along its course there are two:

1. Urban wastewater treatment plant Labin in the City of Labin with the capacity of 8,000 equivalent inhabitants and 9,400 inhabitants connected to the drainage system.

2. Raša drainage system in the Municipality of Raša with 1,590 inhabitants connected to the drainage system.

Considering overflow structures activated during heavy rainfall, there is one in the City of Labin and three in the Municipality of Raša. The type of pollution is mostly domestic wastewater, but there is some industry in the area. In addition, there is agricultural pollution in the sense of chemical pesticides, insecticides, and herbicides. In transitional waters of Raša bay just after the river mouth, bathing waters (BW) are influenced by cargo port Bršica for coal, sand, stone, wood, and livestock. There is the possibility of oil pollution from cargo boats as well and also chemical pollution from antifouling.

As a part of the WATERCARE project, the monitoring included the transitional waters of the river Raša downstream from Most-Raša and Krapanj canal and in the coastal waters in the Raša bay from the mouth of the river to Blaz cove. The aforementioned stated that there is a continuous possibility of bathing waters pollution due to wastewater discharges into the water flow, heavy rainfall that induces overflow, and proximity of the cargo port. All these inputs can cause the exceeding the limit values of the microbiological parameters depending on the meteorological conditions and sea tides and thus make BWs unsuitable for bathing. According to the Assessment of the bathing seawater quality at sea beaches available for the bathing season 2021 on online monitoring tool from Croatian waters, the beaches in the proximity of the river Raša mouth are appointed with overall excellent quality.

5.3.4 Cetina Site (CROATIA)

Cetina river spreads across 1,463 sq km in a length of 105 km in Split-Dalmatia County. The hydrological drainage area covers a territory of over 2,370 sq km. Its source is in Dinara mountain at the height of 385 meters above sea level, near Cetina settlement. From its source to mouth passes near the town of Vrlika where it flows into artificially created Peruća lake (approximately 25 km from the source). After the lake, it flows through the karstic area and Sinjsko field towards the City of Sinj and the City of Trilj. Once it passes Trilj, enters the canyon and flows south towards the mouth, located in the City of Omiš, where it flows into the Adriatic Sea. Along its watercourse, the river receives water from several tributaries and other numerous small springs and sources. Moreover, it is the most water-rich river in Dalmatia with high hydropower potential. Thus, along its stream, there are five hydropower plants built and operational.

Considering the pressures to which the Cetina river is subjected along its watercourse there are several to be appointed, from source to mouth:

1. Mechanical WWTP of the City of Sinj with 10,480 equivalent inhabitants connected to the drainage system out of the total load of the agglomeration of 23,867 equivalent inhabitants.

2. UWWTP of the City of Trilj with a capacity of 3,500 equivalent inhabitants and a bank outlet into the river. The drainage system has 1,975 equivalent inhabitants connected to the system out of the total load of the agglomeration of 5,595 equivalent inhabitants.

3. Pumping stations with overflows to the river, located in Trilj: PS Trilj 1 on the right bank of the river and PS Trilj 2 on the left bank of the river.

4. UWWTP Priko of the City of Omiš and part of the settlement Dugi Rat with the capacity of 30,000 equivalent inhabitants (11,745 equivalent inhabitants are connected to the drainage system out of the total load of the agglomeration of 14,986). The urban WWTP has the submarine outlet into the Brač channel where Cetina flows into and is located on the right bank of the river.

5. Pumping stations with overflows to the river, located in Omiš: PS7 Ribnjak, PS4 Punta and PS5 Cetina.

6. Pumping stations with incidental discharges to the river or transitional waters, located in Omiš: PS3 Buzet and PS6 Most.

The WATERCARE project pilot area refers to the monitoring of the Cetina downstream and the transitional waters on its mouth. The most common pollutants in that area are those discharged from households and enterprises. The most significant potential source of water pollution is maritime transport that commonly discharges polluted bilge water, waste oils and oily water, tank flushing, ballast water changes, and the possibility of accidents can vary from serious to catastrophic. In addition to the traffic of larger ships, an additional possible source of pollution are small boats for recreation and fishing.

All of the above mentions represent a threat to bathing waters quality due to the possible exceeding of limit values of microbiological parameters. According to the Assessment of the bathing seawater quality at sea beaches available for the bathing season 2021 on online monitoring tool from Croatian waters, the beaches in the proximity of the river Cetina mouth (transitional waters) are appointed with overall excellent quality.

5.3.5 Neretva Site (CROATIA)

The river Neretva is shared between Bosnia and Herzegovina and Croatia. The river basin covers over 10,300 sq km altogether, out of which about 280 sq km is in Croatia, more specifically in Dubrovnik-Neretva County. The river is about 220 km long, from the source to the mouth, whereas the final 20 km are in Croatia. The mouth of the river forms an extensive delta with large reedbeds, lakes, wet meadows, lagoons, sandbanks, sandflats and saltmarshes, and is surrounded by karst hills rich with underground water that supplies numerous springs, streams and lakes. Moreover, the river mouth area is characterized by a large number of drainage channels and it represents an ecologically unique area with over 300 registered bird species. The downstream of the riverbed in Croatia flows through the City of Metković, the City of Opuzen and next to the City of Ploče flows into the Adriatic Sea. Also, one branch of the river's delta flows into the sea in the port of Ploče.

When referring to the pressures to which the watercourse is subjected while passing through Croatia (looking from the source to the mouth), there are several to appoint:

1. Pumping stations without overflows in the City of Metković: PS Kneza Domagoja, PS Zrinski-Frankopan and PS Neretvanskih gusara with four bank outlets into the Neretva river without treatment (Mercator Department Store, Put Narone, Unka and Kneza Domagoja Street). 9,617 equivalent inhabitants are connected to the drainage system out of the total load of the agglomeration of 15,979 equivalent inhabitants.
2. Mechanical urban WWTP of the City of Opuzen with a capacity of 1,300 equivalent inhabitants and discharge system to the river. The area has 1,770 equivalent inhabitants connected to the drainage system out of the total load of the agglomeration of 3,902 equivalent inhabitants.
3. Opuzen's pumping stations PS Prantrnovo and PS Zagrebačka without overflows and PS Spomenik with incidental overflow and the drainage system that flows to the river.
4. Three wastewater discharge outlets into the port of Ploče (transitional waters of the Neretva River): Central outlet, Coastal outlet1 and Coastal outlet 2. The drainage system of the City of Ploče has 6,486 equivalent inhabitants connected to the system out of the total load of the agglomeration of 8,577.
5. Pumping station 1 is located in the City of Ploče with an incident overflow into the port of Ploče (transitional waters).

The pilot site location is the mouth of the river Neretva near the City of Ploče. The monitoring includes a sampling of the river water downstream and the transitional waters of the river in the Neretva Channel. This area is intensively used for agricultural purposes for mariculture and tourism, which indirectly affect the pollution and increase the concentration of nutrients in the already naturally eutrophic area. The main ecological threats are expansion and intensification of agriculture, water pollution with non-purified urban and industrial waters, non-regulated recreational and touristic activities, especially on the river mouth.

The intensity of the pollution is related to the level of microbiological parameters present in the bathing waters. In case those limits are exceeded, the BWs in the proximity of the pilot area are not suitable for bathing. According to the Assessment of the bathing seawater quality at sea beaches available for the bathing season 2021 on online monitoring tool from Croatian waters, the beaches in the proximity of the Neretva River mouth (transitional waters) are appointed with overall excellent quality.

6. WORKING METHODOLOGY (WQIS)

The Water Quality Integrated System (WQIS) network was applied and implemented for each study area and focused on urban areas in sewers, riverine and rivers. Innovative Water Quality Integrated System is based on a thorough knowledge of the magnitude, frequency, and impacts of microbial contamination of bathing water due to high rainfall. The system was developed to protect public health, the environment and the economic activities that rely on tourism. Its proactive approach to coastal water quality management can be applied to a variety of coastal sites characterized by extreme raining events.

The WQIS is based on real-time hydro-meteorological monitoring, a forecast model that simulates pollutant dispersion in bathing water, and a real-time alert tool that predicts potential ecological risks related to the bacterial contamination of bathing water after extreme raining events.

The experience gained in the implementation phase of the WQIS in the pilot site has been transferred to the various partners of the project. In particular, the connection diagrams of the equipment, the sampling strategies, and an operating manual regarding the use of the entire WQIS "ecosystem" were shared.

6.1 Sampling systems and tools

The WQIS is an IT ecosystem consisting of several interconnected and continuously interacting subsystems (Fig. 6.1-1).

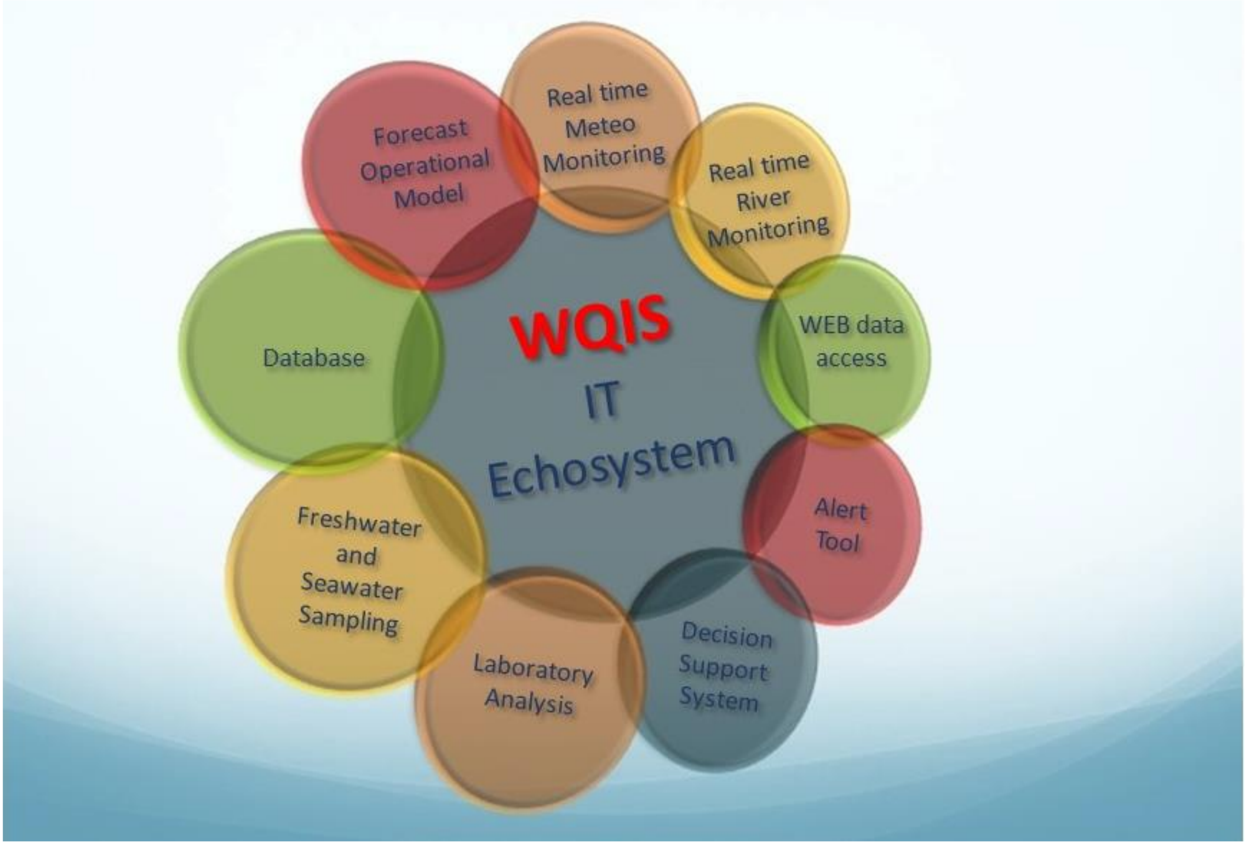


Figure 6.1 - 1 The WQIS IT ecosystem and the integrated subsystem.

In the subsystem named Meteorological, Freshwater, and Seawater monitoring, some activities are automatic and do not require the direct intervention of an operator, whereas other activities, such as seawater sampling and bacteriological and chemical analyses, involve human action. The flow of information stored in the WQIS database is managed by a continuously running software that processes the data by means of a forecast operational model connected to an alert tool.

These tools are the WQIS results and allow generation and delivery of FIB (*Faecal Indicator Bacteria*) dispersion forecast maps, which are then used by decision makers. Therefore, the system outputs real-time data that updates historical series with new data.

The alert tool notifies users of:

● system progress;

● any abnormalities in the environmental parameters;

● any hardware abnormalities detected in real time.

Regarding software engineering, during the various development phases of the Watercare project, the paradigm called Agile Software Development (ASD) was used. Agile methods are opposed to the waterfall model and other traditional development models, proposing a less structured and focused approach on the objective of delivering functioning and quality software (continuous new verifications), quickly and frequently.

An important practice through which the solution to be delivered evolves from what was only an "idea" (a concept, a proposal, a set of needs) to become a valuable product. Iterative development works through cycles of actions / activities (Fig. 6.1-2) that do not change, but which by repeating cyclically lead the 'raw' solution to be refined until it becomes the final product.

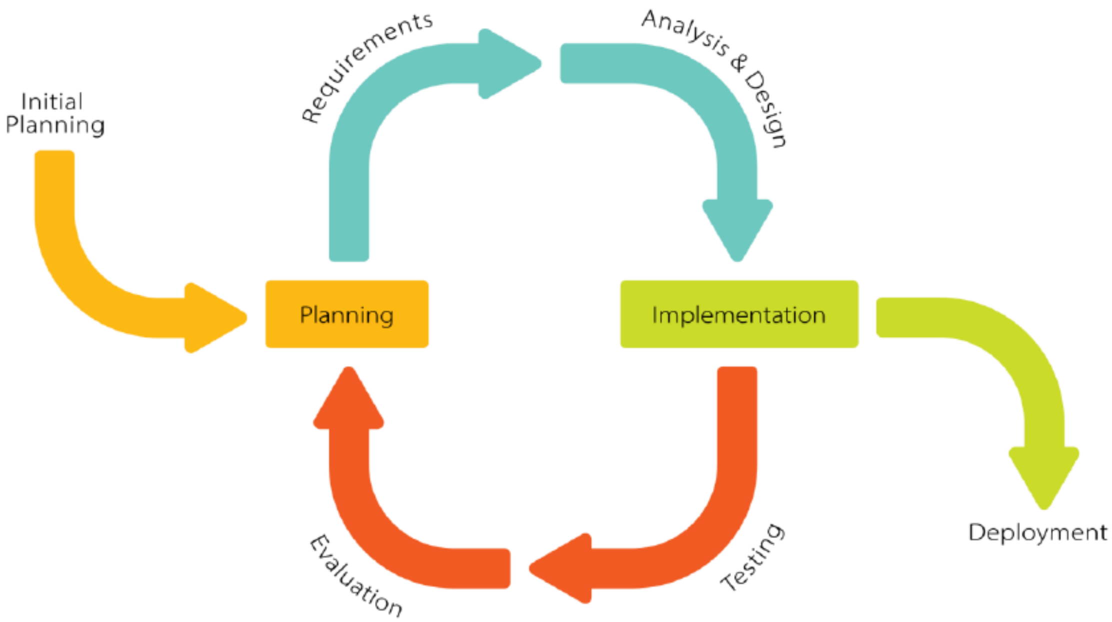


Figure 6.1 - 2 WQIS Iterative development model (modified from Wikipedia, 2021).

6.1.1 List and description for each site

The real-time acquisition system includes the following equipment:

- **Campbell Scientific CR1000X** datalogger that manages the interface with sensors/actuators, data collection and remote communications.

- **Campbell Scientific ClimaVUE50** compact weather station. It measures in real-time the following parameters: wind (speed, gust, direction), air temperature, relative humidity, atmospheric pressure, solar radiation, rain gauges, lightning.

- **YSI EXO2 (or EXO3)** multiparametric probe. The sonde allows real-time river water monitoring measuring the following parameters: level, temperature, salinity, conductivity, Optical Dissolved Oxygen (concentration and saturation), turbidity, pH, redox.

- **Teledyne ISCO Avalanche** automatic and refrigerated water sampler which takes samples (14 bottles, 900ml) for laboratory analysis of microbiological parameters of river water.

- **Siemens Probe LU240** ultrasonic level sensor (Fano only).

Nitrate and ammonia (pH, redox Fano only) are measured with a portable multiparametric sonde in water samples collected with ISCO Automatic sampler.

Table 6.1 - 1 List of the parameter measured for each Watercare site station and the hardware device used.

HARDWARE SENSORS	PARAMETER	FANO Arzilla Upstream	FANO Arzilla Outfall	POLA Rasa River	DUBVRONICK Neretva River	SPLIT Cetina Main	SPLIT Cetina Outfall	PESCARA Pescara River
Weather Station (ClimaVUE™50)	Wind (speed, direction, gust)	–	X	X	X	X	–	X
	Air Temperature	–	X	X	X	X	–	X
	Relative Humidity	–	X	X	X	X	–	X
	Atmospheric Pressure	–	X	X	X	X	–	X
	Solar Radiation	–	X	X	X	X	–	X
	Rain Gauges	–	X	X	X	X	–	X
	Lightning	–	X	X	X	X	–	X
Multiparameter Sonde (YSI EXO2/EXO3)	Water Temperature	X	X	X	X	X	–	X
	Salinity	X	X	X	X	X	–	X
	Conductivity	X	X	X	X	X	–	X
	Optical Dissolved Oxygen (concentration and saturation)	X	X	X	X	X	–	X
	Turbidity	X	X	X	X	X	–	X
	pH	–	–	X	X	X	–	X
	Redox	–	–	X	X	X	–	X
Level Sensor (Siemens SITRANS LU240)	River Level	X	–	–	–	–	–	–
	River Flow Sensor	**Estimated by model**	–	–	–	–	–	–

Table 6.1 - 2 Hardware devices measured parameters and WQIS stations.

HARDWARE SENSORS	PARAMETER	FANO Arzilla Upstream	FANO Arzilla Outfall	POLA Rasa River	DUBVRONICK Neretva River	SPLIT Cetina Main	SPLIT Cetina Outfall	PESCARA Pescara River
Datalogger Cambpell Scientific		X	X	X	X	X	X	X
ISCO Avalanche Sampler		X	X	X	X	X	X	X
Power Source		**230V**	**230V**	**230V**	**12V Battery Photovoltaic panel**	**12V Battery Photovoltaic panel**	**230V**	**230V**

Table 6.1 - 3 List of WQIS equipment.

Ref	Image	Description	Station
1	  	**Datalogger Campbell Scientific CR1000X and Router LTE (Inhand IR915L or Teltonika)** The CR1000X is a low-powered device designed to measure sensors, drive direct communication and telecommunications, analyse data, control external devices, and store data and programs in on-board, non-volatile storage. A battery-backed clock assures accurate timekeeping. The on-board, BASIC-like programming language—common to all Campbell Scientific data loggers—supports data processing and analysis routines. The CR1000X wiring panel includes two switchable 12 V terminals, analog grounds dispersed among 16 analog terminals, and unpluggable terminal blocks for quick deployment. The router allows access to the datalogger remotely and connects it with the loggernet server.	Fano Arzilla Outfall Fano Arzilla Upstream Pola Rasa River Dubrovnik Neretva River Split Cetina Main Split Cetina Outfall Pescara Pescara River

2		**YSI EXO2/EXO3 Multiparameter Sonde** EXO2 is a Multiparameter Water Quality Sonde with 7 sensor ports (4 ports for the EXO3 version). It includes a central wiper and battery compartment. EXO is an extremely versatile instrument for unattended monitoring, allowing the user to automatically configure a sonde with different sensors for different applications. The smart sensors installed are Conductivity/Temperature, Dissolved Oxygen, pH & ORP, Salinity and Turbidity. The EXO communicates with the datalogger via SDI-12 protocol. https://www.ysi.com/exo2	Fano Arzilla Outfall Fano Arzilla Upstream Pola Rasa River Dubrovnik Neretva River Split Cetina Main Pescara Pescara River
3		**Teledyne ISCO Avalanche Water Sampler** ISCO Avalanche is a multifunction refrigerated sampler with the function of automatically sampling up to 14 bottles. it can be controlled locally using the commands and the local display or remotely via datalogger (the communication between the two devices is via RS232 serial protocol). https://www.teledyneisco.com/en-us/water-and-wastewater/avalanche	Fano Arzilla Outfall Fano Arzilla Upstream Pola Rasa River Dubrovnik Neretva River Split Cetina Main Split Cetina Outfall Pescara Pescara River

4		**Campbell Scientific ClimaVUE50** The ClimaVUE™50 is an all-in-one meteorological sensor. This sensor uses SDI-12 to report air temperature, relative humidity, vapor pressure, barometric pressure, wind (speed, gust, and direction), solar radiation, precipitation, and lightning strike (count and distance). https://www.campbellsci.com/climavue-50	Fano Arzilla Outfall Pola Rasa River Dubrovnik Neretva River Split Cetina Main Pescara Pescara River
5		**Verdeflex Dura 7 peristaltic pump** Verdeflex Dura 7 is a compact and high pressure peristaltic pump used for pumping water from the river to the flow cell for water analysis via EXO2/EXO3. The pump is powered in three-phase 380V through a 220V-380V inverter controlled by the datalogger (it manages the switching on and off of the pump). The datalogger checks the pump temperature by analysing the resistance across a PTC installed in the pump motor. https://verderflex.com/it/pompe-peristaltiche-industriali/verderflex-dura	Fano Arzilla Outfall Fano Arzilla Upstream Pescara Pescara River

6		**Siemens Probe LU240 ultrasonic level transmitter** Siemens LU240 is a compact level sensor for river level measurement. The transducer converts the level into a current (current loop 4-20mA) which is then read by the datalogger and converted into a value in meters. https://new.siemens.com/global/en/products/automation/process-instrumentation/level-measurement/continuous/ultrasonic/sitrans-probe-lu240.html	Fano Arzilla Outfall
7		**Campbell Scientific LR4 relay module** LR4 is a relay module with 4 relays that mechanically latches the relay's state, allowing power to be removed. The only way to change the state of a relay is to send a command to the LR4 or to press the manual toggle button. The datalogger sends commands to the LR4 via the SDI-12 protocol or ModBus protocol. This module is used to control the peristaltic pump and cabinet air extractor. It also controls a signaling led strip. https://www.campbellsci.com/lr4	Fano Arzilla Outfall Fano Arzilla Upstream Pescara Pescara River

6.2 Points, period and frequency of sampling

A fundamental step concerning the plan and implementation phase was to study the subsystems and sensors, taking particular care of communication, energy consumption, physical connection, and the format of the data output. During this activity, the most delicate procedure consisted of the implementation and test of the scripts for the management of communication, data reading and data transfer between the datalogger and each sensor.

Subsequently, a complete abstracted firmware and software was implemented: all the source codes produced in the previous step were integrated into subroutines and functions were inserted into a complete reading cycle performed every 30 minutes (the sensor reading routines are performed almost continuously and subsequently processed every 30 minutes).

The conceptual model of the management of the acquired data is composed of different levels (Fig. 6.2-1).

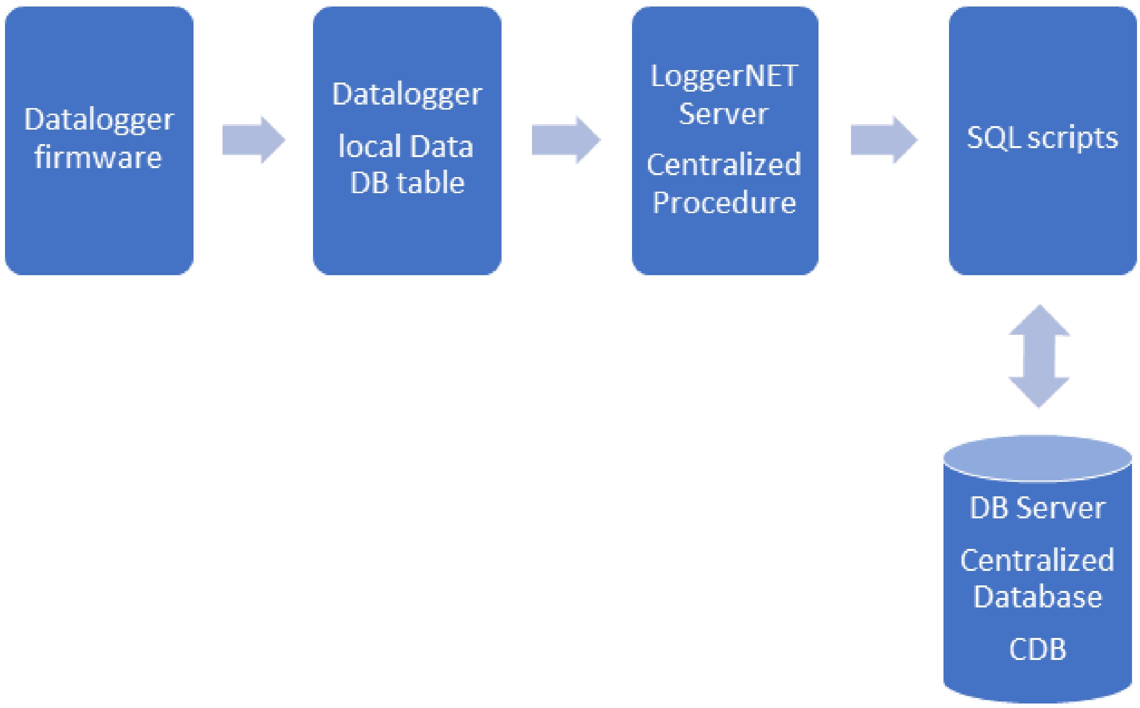


Figure 6.2 - 1 Block diagram of real-time data acquisition.

The datalogger firmware is responsible for interfacing with the sensors and it manages the real-time reading of the signals (analog and/or digital) output from the sensors. Data is processed and stored locally. Every 30 minutes data is then reprocessed to be collected in a single record and inserted into a pre-configured datalogger table. The Campbell Scientific's LoggerNet software retrieves in real-time raw data from remote dataloggers and inserts it into the WQIS Centralized Database (CDB).

The automatic activity is based on a real-time data acquisition system operating through an embedded system that consists of a data logger (Campbell Scientific CR1000X), a 4G communication system, a compact weather station (Campbell Scientific CLIMA VUE50), and a CTD multiparameter probe (YSI EXO2). A river-level ultrasound sensor (Siemens SITRANS LU240) is installed at the river mouth. A dedicated firmware is created to integrate the above systems. Data from these systems are collected at time intervals of 30 min and sent via the mobile network to the master station for storage in a dedicated database. The CTD (Conductivity, Temperature, Depth; Dissolved Oxygen; Turbidity) multiparameter probe is housed in a flow cell connected to a peristaltic pump. The pump is activated for 15 min before data reading to ensure adequate water flow and pipe cleanliness.

Automatic freshwater sampling for microbiological and chemical analyses is activated by a trigger event, e.g., heavy rain detected by the weather station, a rise in the river level, or CSO (Combined Sewer Overflows) activation. Seawater sampling starts after CSO closure, its schedule adapted to weather and sea conditions. A time diagram showing the freshwater and seawater sampling phases is reported in the next Fig. 6.2-2.

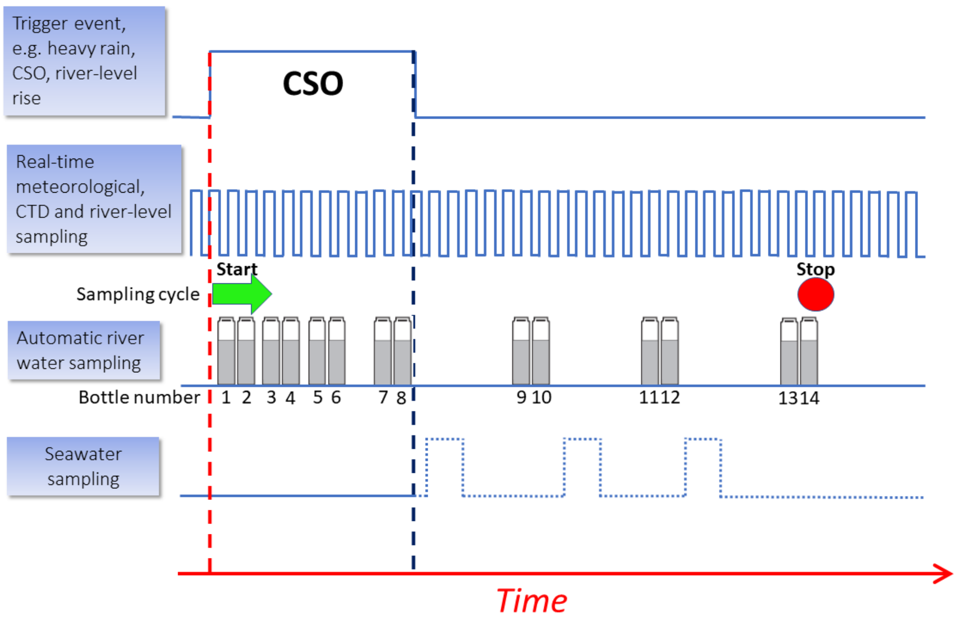


Figure 6.2 - 2 Time diagram (arbitrary scale) showing the water sampling phases activated by a Combined Sewer Overflows (CSO) event (Penna P. et al, 2021).

The autosampler, an ISCO Avalanche 6712 which provides for sample refrigeration, contains 14 bottles (capacity, 950 ml). The advantage of using this apparatus is that the sampling time scale can be set up remotely by the scientific site manager and adapted to the intensity of the meteorological event.

Upon system activation by the trigger event, the data logger sends a command to the autosampler to collect the freshwater samples and place them into bottle n and bottle n + 1. The water in bottle n is used for chemical-physical analysis whereas the content of bottle n + 1 is used for microbiological analysis. The samples are kept at 3–4 °C throughout the sampling cycle. At the end of the cycle the bottles are capped and replaced with new sterilized bottles for the next automatic sampling. All phases are monitored by the real-time data acquisition system, which reports any abnormalities via the alert.

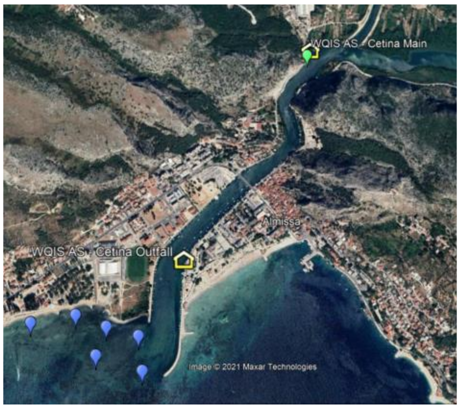
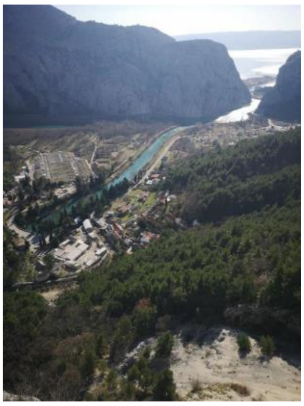
6.2.1 List and description for each site

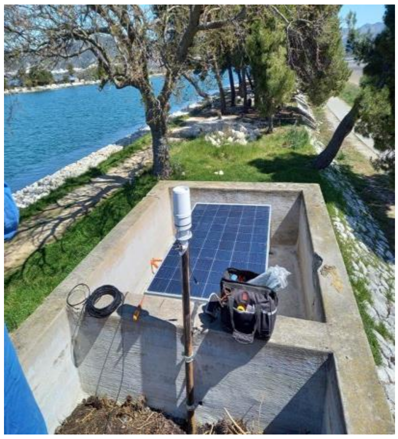
Meteorological/hydrological sensors as remote stations were installed in 5 different Watercare sites and they are summarized in the following table.

Table 6.2 - 1 Equipment and sensors installed in five Watercare sites.

Site	Map	Meteo station	Multiparametric probe	AVALANCHE Automatic Sampler	Web data flow start	Equipment and sensors installed
Fano Arzilla Outfall (Pilot site)		X	X	X	26/08/19	 

Fano Arzilla Main (Pilot site)			X	X	28/05/20	 
Pola Rasa	 	X	X	X	04/03/20	 

Split Cetina Main		X	X	X	06/05/21	 
Split Cetina outfall				X	06/05/21	 

Dubrovnik Neretva		X	X	X	23/03/21	 
Pescara Pescara		X	X	X	27/05/21	 

CNR IRBIM staff has developed a web interface, named Sample Analysis (S.A), with the task of acquiring manual monitoring data, such as data from chemical and microbiological analyses performed by the authorized personnel. Samples Analysis has been developed using html, php and JavaScript language, in addition to jQuery and Datatables for interfacing with the database.

The data included in S.A are integrated into the dedicated DataBase and made available for the web data visualization and for the FOM model.

The samples taken by the ISCO Avalanche automatic sampler are automatically added in the WQIS CDB and they are shown directly in the web interface to simplify the insertion procedure of the data and to reduce the risk of human typing error.

When automatic sampling is in progress and after each ISCO Sample, a new record will be automatically filled with the following information: timestamp, location, typology, site, sampling mode and sample. The operator can then insert the analysis results by selecting the corresponding sample record and then by clicking on the *Edit Sample* button in the command bar. The interface also provides the possibility to insert new manual sample records.

Considering the need of some project partners to process the data locally, the possibility of exporting the S.A. data has also been enabled. Sample analysis interface provides the possibility to export the data analysis into Excel or CSV files.

CNR IRBIM staff has developed a centralized database (WQIS CDB) using the relational database management system (RDBMS) MySQL and it is the heart of the collection project data (sensors data, analysis results, ancillary data, project partners registers, access information to project websites, geolocation sampling points, etc). The interoperability of data is guaranteed using an internationally recognized vocabulary (British Oceanographic Data Centre-NERC Vocabulary Server) and data format (ODV Ocean Data View).

The data acquired and collected are analysed and visualized using Grafana (Grafana Labs, 2020) open-source software installed on a dedicated web server at the CNR-IRBIM (Figure 6.2-3).

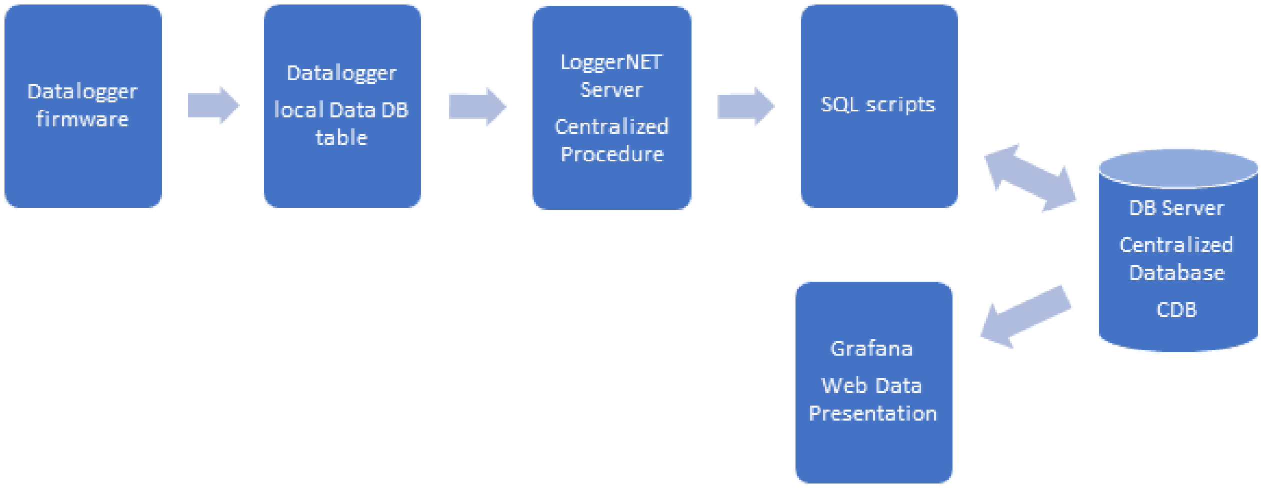


Figure 6.2 - 3 Block Diagram showing the procedure for acquiring, storing, and displaying data.

CNR IRBIM staff has developed a dashboard for each project site to display graphs and statistics of all parameters analysed (air, water, chemical, physical, and microbiological). The dashboard of each Watercare site is characterized by a set of panels (the basic data visualization building block). Each panel allows one or more physical parameters to be plotted and correlated versus time. Furthermore, through the Grafana web interface it is possible to access the site management pages.

The web interface is protected and accessible with the credentials that the CNR-IRBIM staff has provided to all partners. Once logged in, the user is redirected to the Watercare Sites homepage with a summary map of all the project sites (Figure 6.2-4).

Figure 6.2 - 4 Watercare Sites Map.

From the map the user can click on the markdown focused on the site of interest and then open the Data visualization link to open the dashboard with site data and information (Figure 6.2-5).

Figure 6.2 - 5 Direct Links to Web Data Visualization, Site Management and Samples Analysis. The screenshot shows links to the Cetina River outfall site.

The analysis points panel shows a map with all the sampling points provided for the specific site. The points are georeferenced and are extracted from the database. The user can see the sample id by hovering the mouse over the point (Figure 6.2-5).

Figure 6.2 - 6 Shows the Fano Arzilla Outfall map with the sampling points.

In addition, an intuitive section, named Last observation (an example in Figure 6.2-7), has been added for viewing the latest data received.

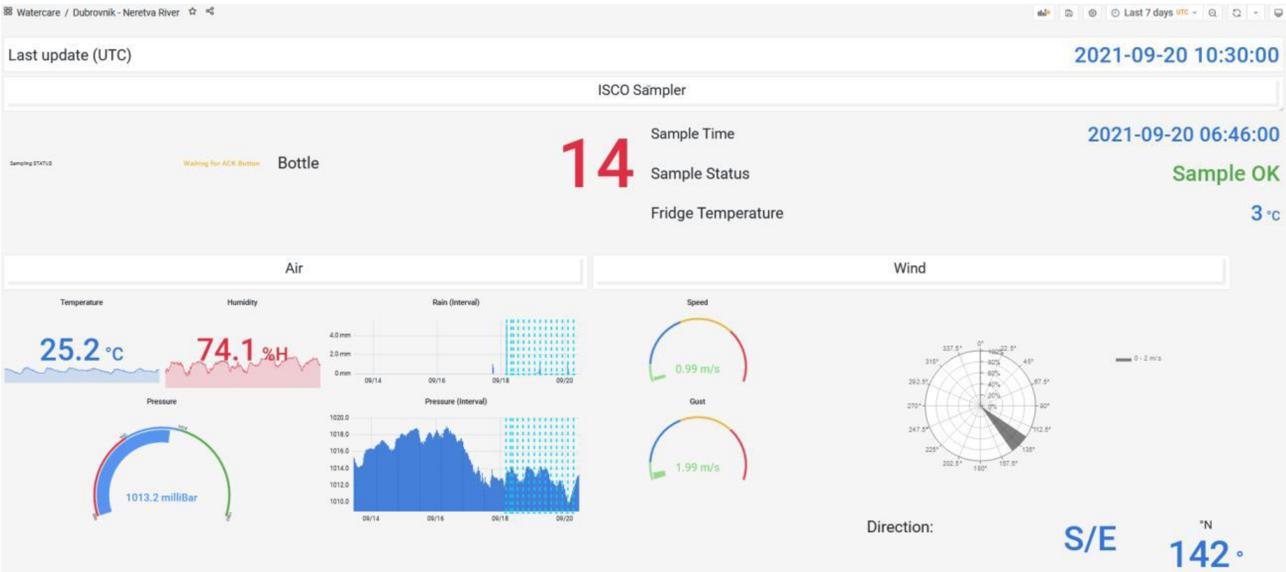


Figure 6.2 - 7 Last observation - Neretva River.

6.2.2 Ancillary environmental data

To ensure an exhaustive knowledge of the Fano pilot site, ancillary data were obtained from:

● a pluvial-hydrometric station (located at Santa Maria dell' Arzilla, about 10 km from the pilot site) managed by the Marche Region Civil Protection (Figure 6.2-8).

● Regional Agency for Environmental Protection of Marche (ARPAM) (Figure 6.2-9 and 6.2-10).

● Italian Health Ministry (Italian Ministry of Health, 2014); http://wwww.portaleacque.salute.gov.it.

● Urbino University (time series data from 2000 to 2014) (Figure 6.2-11).

Figure 6.2 - 8 Rainfall temporal trend and river level measured in the stations of Fano Arzilla outfall and Santa Maria dell'Arzilla (about 10 km away based on ancillary data).

Figure 6.2 - 9 ARPAM sampling points. In order from the north: IT011041013032 (Arzilla Via della Baia), IT011041013005 (30 M NORD TORRENTE ARZILLA) and IT011041013006 (SPIAGGIA LIDO 100 M SUD MOLO ARZILLA).

Figure 6.2 - 10 Example of ARPAM data. The sampling points IT011041013006 (SPIAGGIA LIDO 100 M SUD MOLO ARZILLA) and IT011041013005 (30 M NORD TORRENTE ARZILLA) correspond respectively to the coordinates 43.852253, 13.011380 and 43.853367, 13.009494.

Figure 6.2 - 11 Urbino University sampling point.

The ancillary data are fundamental for the knowledge of the rain-river-sea system located in the Arzilla basin, since before the implementation of the WQIS stations in the pilot site, there was no knowledge of local hydrodynamics. In addition, as shown in Figure 6.2.8, these data proved to be very useful for having feedback on the functioning of the rain and level sensors installed during the project and therefore they represent the validation of actual data.

In the Pescara and Croatian stations, the ancillary data were used for local validations and to obtain useful information for the purposes of the project, even though they were not integrated into the WQIS centralized Database.

6.2.3 Forecast Operation Model

A finite element hydrodynamic model was applied to five study areas in the Adriatic Sea, which differ for urban, oceanographic, and morphological conditions. With the help of transport-diffusion and microbial decay modules, the dispersal of E. coli concentration is simulated and forecasted (*Ferrarin et al., 2021*).

The modelling framework presented here is based on the System of HydrodYnamic Finite Element Modules (*SHYFEM, Umgiesser et al., 2014*) code, an open-source unstructured ocean model for simulating hydrodynamics and transport processes at very high resolution.

The modelling suite consists of:

● a 3D hydrodynamic model, that describes currents and mixing of water mass in the system;

● a transport and dispersion module, that simulates the dispersion of solute and microorganisms through the system;

● a microbial decay module, which defines the decay of microorganisms considering various environmental conditions.

The model runs in a full 3-D baroclinic mode with the water column discretized in zeta or hybrid (mixed sigma and zeta) layers with varying thickness (see the site-specific settings illustrated below). The discharge of the sewerage outlet is simulated with a Eulerian approach, where the concentration of E. coli is prescribed in outflow and the impact of the concentration is evaluated on the coast.

The simulations are forced:

● at the sea open boundary by sea temperature, salinity, water level and currents conditions obtained from the TIRESIAS operational system of the Adriatic Sea (*Ferrarin et al., 2019*). Such an unstructured oceanographic model reproduces in detail the general circulation in the Adriatic Sea, as well as several relevant coastal dynamics, like tidal amplification, saltwater intrusion, storm surge and riverine water dispersion;

● at the sea surface by meteorological data (air temperature, solar radiation, humidity, cloud cover, mean sea level pressure, wind speed and direction) from the high-resolution MOLOCH model (*Davolio et al., 2015*). The MOLOCH model is implemented with a horizontal grid spacing of 1.25 km, and with 60 atmospheric levels and 7 soil levels and provides the meteorological parameters at hourly frequency;

● at the river boundary by forecasted water discharge time series at the Fano pilot site and by climatological river discharge at the other study sites.;

● at the pollutant sources by bacteria concentration and water volume according to the available site-specific data.

In all study sites, the numerical domain considers the area of interest and a larger part of the coastal and shelf seas. To adequately resolve the river-sea continuum, the grids also include the lower part of the considered river (Fig. 6.2-12). The use of elements of variable sizes, typical of finite element methods, is fully exploited, in order to suit the complicated geometry of the coastal sites. The resolution of the triangular elements varies from 1-2 km in the open sea to a few meters near the river mouths and close to the beaches. The bathymetry interpolated onto the numerical grids was obtained by merging high-resolution site-specific datasets covering the area of interest with the composite EMODnet dataset (EMODnet Bathymetry Consortium, 2020) for the outer open sea.

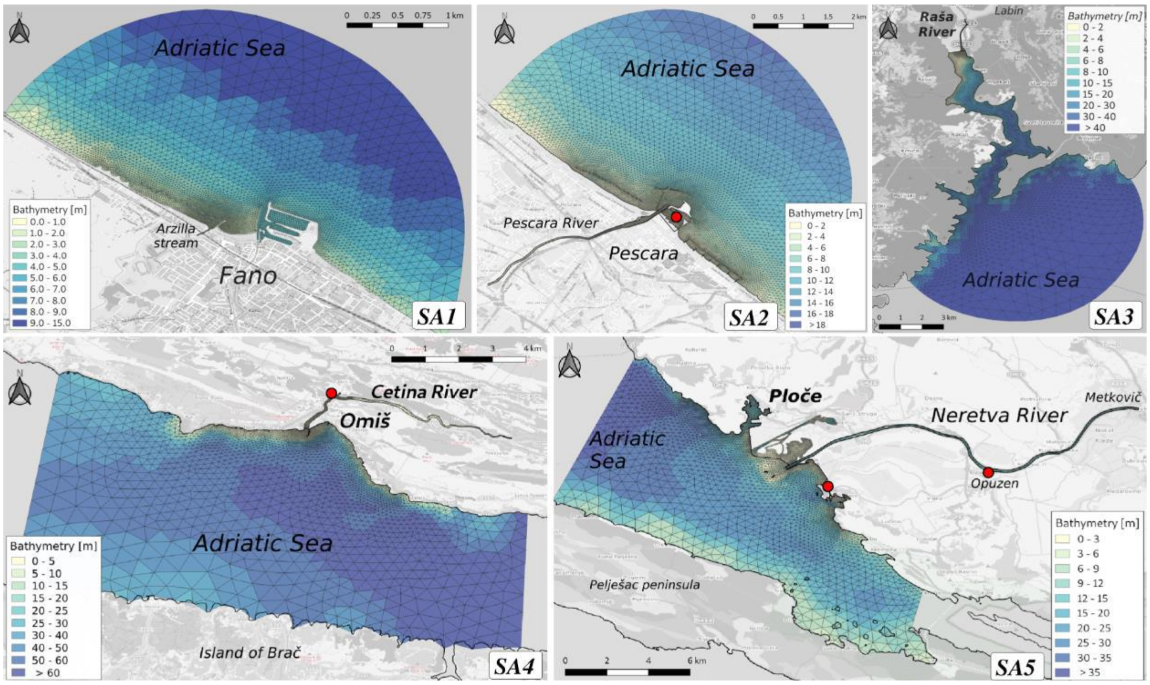


Figure 6.2 - 12 Numerical grids with the superimposed bathymetry of the five target areas.

Model results were evaluated against water level, sea temperature, salinity and E. coli concentrations acquired in situ, demonstrating the capacity of the modelling suite in simulating the circulation in the coastal areas of the Adriatic Sea, as well as main transport and diffusion dynamics, such as riverine and polluted waters dispersion.

The operational system chain (FOM) consists of a daily cycle of numerical integrations. Every day a two-day forecast is produced, with the initial conditions from a hot start based on the FOM forecast of the previous day. The system performs a 2 day-long simulation, and the results (water temperature, salinity and E. coli concentration) are shared through a THREDDS data server and integrated into the WQIS (Fig. 6.2-13).

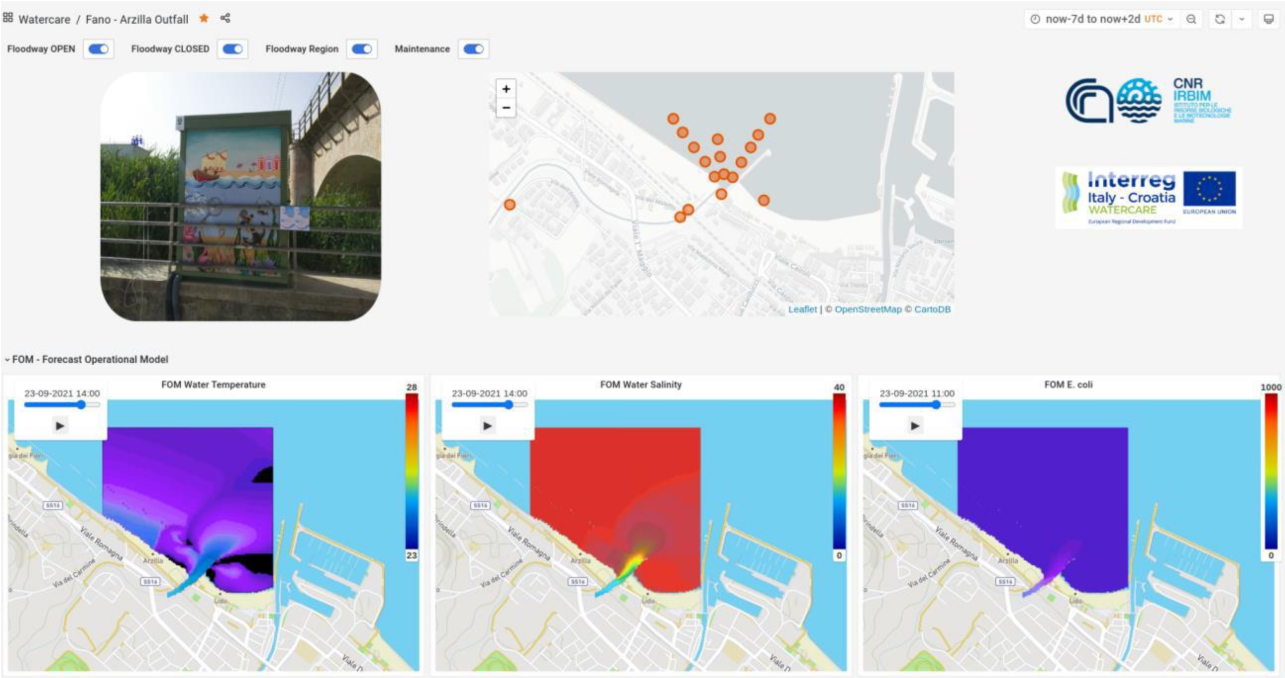


Figure 6.2 - 13 Example of visualization of the FOM at Fano pilot site in section 3.8 WEB data presentation and sharing.

More details can be found in the Deliverables:

D.3.3.1_WATERCARE WQIS Implementation_vfinal,

D.3.3.2_WATERCARE_Sensor Data Web_vfinal

D.4.1.2_Implementation_realization of the WQIS in the pilot site_vfinal

D.5.1.1_Alert Tool for the Bathing Water Management_vfinal

written by Project Partner CNR-IRBIM.

6.2.4 Alert tool

The alert tool is detailed in the deliverable of the WP5 as follows:

5.2.1 – Simulations for the validation of the Alert Tool.

5.2.2 –Alert Tool final release.

written by Project Partner CNR-IRBIM.

6.3 Microbial contamination indicators

6.3.1. Sampling Strategy

The analyzed microbial and environmental data were used to implement the Integrated Water Quality System (WQIS) proposed in the WATERCARE project. The aim of this section is to associate significant environmental variables indicating fecal load and contamination in water to microbial contamination (faecal contamination). The following guidelines on sampling strategy and analyses on various microbial and environmental variables will be useful for various stakeholders to implement new reliable sampling strategies and mitigation measures to avoid the closure of bathing areas for unnecessary periods of time such as now it occurs. In this chapter, the following points have been focused: i) evaluation of the presence and quantification of faecal pollution and its space-time variability along a coastal area affected by river discharges; ii) analysis of the potential relationships of the abundance and distribution of faecal bacterial indicators with the main environmental variables; iii) identification of the origin and time of decay / persistence of microbial contamination during extreme rain events.

6.3.2 Characterization of Fano pilot site

The study area of the pilot site is the Arzilla River and the bathing waters in front of the city of Fano (Marche Region, northern western Adriatic Sea). This area was selected as a pilot site since this site shows the typical characteristics of a medium urbanization city on the Adriatic Sea with a touristic and commercial harbour located near the mouth of the Arzilla River and on the coast which is characterized by numerous artificial barriers against the coastal erosion. The Arzilla stream collects sewage from the hinterland and CSO of Fano which is discharged into the sea, near beaches highly attended during the summer season. Intense rain events often cause the overflow of the local sewerage system that collects the microbial load from the municipality of Fano. Whenever there is a sewer run-off in the summer period, the bathing activity is closed based on the potential risk of faecal microbial contamination (Penna et al., 2021).

6.3.3 Sampling frequency of Fano pilot site

Two bathing seasons were considered from May to September 2019 and 2020, during which river and seawater samples were collected. Freshwater samples from the Arzilla River were collected in a 30 min time interval during rain events and every 6, 12 or 24 hours after rain events using the autosampler system located at the Arzilla estuary and in an upstream station before the CSO of the first rain collection tank (Fig. 6.3 -1). Samples were collected for determination of faecal bacteria, dissolved inorganic nutrients (ammonia-NH4, nitrite-NO2, nitrate-NO3, total nitrogen, total phosphorus), total suspended solid (TSS), particulate organic matter (POM) and chlorophyll-a content characterizing the freshwater body that flowed into the sea (Table 1). At the end of each rainy event, surface seawater samples were manually collected with sterilized bottles in front of the Arzilla mouth, within 250 m from the coastline, for chemical and microbiological analyses. The sampling spatial scale followed a grid composed of three transects (Transects 1, 2 and 3) along with a point in the Arzilla mouth (Fig. 6.3 -2). Each transect includes points at 50, 100, 150, 200 and 250 m from coastline; the Transect 2 includes only three sampling points (i.e. 50, 100 and 150 m). This small spatial scale sampling strategy was adopted following the coastal morphology, bathymetry of the area, water currents and the presence of artificial barriers that influence the microbial dispersion. Furtehr, at each site, temperature (°C), salinity, pressure, density (στ), oxygen concentration and saturation, pH, redox and Chl a were measured using a CTD multiparametric probe (Idronaut model Ocean Seven 316 Plus).

Figure 6.3 - 1 Study site and sampling strategy; a) two sampling stations are positioned along the Arzilla River, Arzilla outfall (where is located the automatic water sampling for microbiological and chemical analyses) and at Arzilla upstream; b) discharge point or CSO (combined sewer outflow) and automatic sampling station.

Figure 6.3 - 2 Map of seawater sampling in front of the Arzilla mouth. Sampling stations are distributed along three transects (transect 1 in red, transect 2 in blue, transect 3 in yellow) at increasing distance from the shore with different sampling points: 50m, 100m, 150m, 200m, 250m from the mouth.

6.3.4 Microbiological analysis

Field of river and seawater samples for microbiological analyses of faecal contamination (Escherichia coli and intestinal enterococci) were immediately carried out to the laboratory at in situ temperature in the dark and processed within a few hours after collection. E. coli and enterococci bacteria were analysed using culture-based methods. E. coli abundance was determined by membrane filtration. An appropriate volume of water (from 1 to 100 ml) was vacuum-filtered (pore size 0.22 µm, diameter 47 mm; Millipore) in triplicate and the filters were placed on m-FC agar plates and were incubated at 44.5 °C for 24 h. Only blue colonies were considered. The abundance was reported as CFU (Colony-Forming Units) 100 ml−1 of water. Enterococci abundance was assessed by membrane filtration and an appropriate volume (from 1 to 100 ml) were filtered in triplicate as described above and filters were placed on Slanetz Bartley agar plates. Plates were incubated at 37.5 °C for 48 h. Only red or reddish-brown colonies were considered as presumptive enterococci. The abundance was reported as CFU 100-1 ml of water filtered.

6.3.5 Environmental parameters analyses

River and seawater samples for nutrient analyses were filtered (nitrocellulose Millipore, 0.45 µm) and stored at −20 °C in polyethylene bottles until analysis, whereas water samples for TSS (total suspended solid), POM (particulate organic matter) and Chl a were filtered on GF/F Whatman, 0.7 µm and on nitrocellulose Millipore, 0.45 µm filters, respectively, and immediately processed. Nutrient concentrations were measured using a UV-1700, Shimadzu model following Strickland and Parsons (1972). N-TOT and P-TOT were determined on unfiltered water samples according to the method of Valderrama (1981). Accuracy was ± 0.02 µmol l−1 for N-NH4, N-NO2, N-NO3, N-TOT, P-TOT. A calibration curve was made with 5 levels of Merck standards and the accuracy was tested using a standard as sample. The precision was tested on 10 replicates of the standard and were: ±0.001 µmol l−1 (N-NH4), ±0.006 µmol l−1 (N-NO2), ±0.005 µmol l−1 (N-NO3). TSM concentrations were determined gravimetrically by filtration of a known volume of water sample through 0.7 µm pre-combusted and pre-weighed GF/F membrane filters (Millipore, Bedford, MA, USA) following APHA (2017). For PIM and POM determination the filters were then ashed at 500°C for 1 h following the APHA Loss On Ignition (LOI) method. POM concentrations were calculated by difference between TPM (total particulate matter) and PIM (particulate inorganic matter). The precision estimated on 5 replicates by coefficient of variation was < 10%. Chl a concentration was determined in 90% acetone homogenates of particulate matter collected on filters as described above. The Chl a was analysed spectrophotometrically.

Table 6.3 - 1 List of meteorological, physical, chemical, and microbial parameters analysed in river and seawater in Italian target sites.

	Method (Manual, Automatic, Lab)	
PARAMETERS	**Riverine**	**Seawater**
Meteorological data		
Rainfall (mm/m² and length of time)	√	
Wind (speed and direction)	√	
Solar Radiation (%)	√	
Sea water current	N--NE--E--SE--S--SW--W--NW	
Sea state (waves)	√	
Chemical/physical data		
Salinity	√	√
Temperature (°C)	√	√
Redox (mV)	√	√
pH	√	√
Conductibility (mS/cm)	√	√
BOD_5 (mg/L)	√	
COD (mg/L)	√	
Turbidity (NTU)	√	√
Dissolved O_2 (% sat)	√	√
Dissolved O_2 (mg/L)	√	√
Chlorophyll *a* (µg/L)	√	√
TSS (mg/L)	√	√
POM (mg/L)	√	√
Ammonium N-NH_4 (µM)	√	√
Nitrates N-NO_3 (µM)	√	√
Nitrites N-NO_2 (µM)	√	√
TN (µM)	√	√
TP (µM)	√	√
Ortho-phosphate P-PO_4 (µM)	√	√
Microbiological data		
Faecal Indicator Bacteria (*Escherichia coli* and *Enterococcus*)	√	√

6.3.6 Characterization of Pescara site

The area under study is rather limited, it affects the Abruzzo coast close to the Pescara port area, the terminal stretches and the mouth of the Pescara River, the area surrounding the breakwater built to protect access to the port.

Figure 6.3 - 3 Location of Pescara site.

The sampling plan took into account the data relating to currents and the geomorphology and bathymetry of the seabed, previously analyzed by the client. (Table 2) from which we try to verify and create models of the distribution of water following rainy events.

1) The inclination of 25 ° NNW with respect to the geographic north of the coast line of the submarine pipeline, due to the presence of a coastal oil terminal.

2) The characterization of the sediment accumulation areas, near the breakwater with an orientation almost EAST – WEST.

3) The formation of currents which interacting with these structures have modified the dilution modalities or the increases in concentration of the chemical and organic substances under study.

Table 6.3 - 2 Sampling stations with indication of GPS coordinates.

Sampling stations	Latitude	Longitude
PPS 1	42.470902	14.227755
PPS 2	42.470172	14.224811
PPS 3	42.472041	14.225916
PPS 4	42.473306	14.229538
PPS 5	42.471478	14.233852
PPS 6	42.470416	14.222372
PPS 7	42.470322	14.236976
PPS 8	42.472295	14.217908
PPS 9	42.463456	14.238191
PPR 1	42.445957	14.186422
PPR 2	42.461686	14.210923
PPR 3	42.465148	14.221217
PPR 4	42.469744	14.229630
AS Automatic sampling	42.466327	14.224545
IT013068028012	42,470249	14,220312

In relation to the foregoing, and to understand the area of influence of the waters leaving the port, in the context of a preliminary survey of the area concerned, nine sampling stations at sea, 4 sampling stations on the river were selected. The installation of an automatic sampler always on the river and a station near the shoreline. The stations are located at progressive distances from each other to uniformly cover the area for the creation of the distribution model.

For each point the analyzes are aimed at evaluating the horizontal variation of the concentrations of both the chemical and organic characteristics (Fig. 6.3-4).

Figure 6.3 - 4 Location of sampling points.

Sampling frequency

The sampling schedule to be carried out considered the samplings already foreseen for the ordinary monitoring activities carried out during the bathing season by ARTA Abruzzo.

They were carried out over a period in stable conditions and in adverse weather conditions.

The following table shows the dates and number of samplings performed.

Table 6.3 - 3 Dates and number of samplings performed.

SAMPLING PLAN				
WEATHER CONDITION	CALENDAR	REPETITIONS	AUTOMATIC SAMPLING	SAMPLES OF THE SEAWATER AND RIVERWATER
NORMAL WEATHER	12/07/2021	4x during the bathing season	1 sample	1 sample for each point: 4 river points 9 sea points
	26/07/2021			
	09/08/2021			
	06/09/2021			
HEAVY RAIN EVENT	20/07/2021	6x during the bathing season	14 samples	1 sample for each point: 4 river points 9 sea points
	26/08/2021			
	31/08/2021			
	29/09/2021			

6.3.7 Description of the other target sites

All Croatian sites are described, such as Cetina, Neretva, Rasa as listed in Table 3.

Table 6.3 - 4 Croatian sampling site description.

Nr.	Pilot site	Stat_code	X_HTRS	Y_HTRS	LAT	LONG
1.	Cetina	AP_Cetina_1	515172	4811276	43,44124	43,44124
2.		AP_Cetina_2	515766	4812338	43,45079	43,45079
3.		PV_C_0 m	514985	4810921	43,43805	43,43805
4.		PV_C_T1_150m	514840	4810960	43,4384	43,4384
5.		PV_C_T1_300m	514699	4811011	43,43886	43,43886
6.		PV_C_T2_200m	514804	4810837	43,43729	43,43729
7.		PV_C_T3_150m	515011	4810773	43,43671	43,43671
8.		PV_C_Autokamp Zapad	514502	4810976	43,43855	43,43855
1.	Neretva	AP Neretva	577282,3	4764963	43,02055	17,44818
2.		PV_N_0m	576900	4764885	43,01989	17,44348
3.		PV_N_T1_200m	576856,1	4765022	43,02113	17,44296
4.		PV_N_T2_200m	576740,2	4764812	43,01925	17,44151
5.		PV_N_T2_400m	576560,6	4764690	43,01817	17,43929
6.		PV_N_T3_200m	576963,7	4764659	43,01785	17,44423
7.		PV_N_SPRUD 1	576709	4764396	43,01551	17,44107
8.		PV_N_SPRUD 2	576582,1	4764377	43,01535	17,43951
9.		PV_N_PLOČE UŠĆE 1	577778,5	4764907	43,02	17,45426
10.		PV_N_PLOČE UŠĆE 2	577137,7	4764694	43,01815	17,44637
11.		PV_N_PLOČE UŠĆE 3	577165,7	4764672	43,01795	17,44671

12.		PV_N_PLOČE UŠĆE 4	577277,3	4764685	43,01805	17,44808
1.	Raša	AP_Raša	307005,2	4992833	45,04919	14,04994
2.		Krapanj	307025,6	4992700	45,048	14,05025
3.		PV_0	306818,4	4990986	45,03253	14,04828
4.		PV_T1_200m	306654,7	4990867	45,03142	14,04625
5.		PV_T1_400m	306479,9	4990801	45,03078	14,04406
6.		PV_T1_600m	306271,4	4990740	45,03017	14,04144
7.		PV_T2_200m	306669	4990768	45,03053	14,04647
8.		PV_T2_400m	306582,4	4990591	45,02892	14,04544
9.		PV_T3_200m	306838,6	4990794	45,03081	14,04861
10.		PV_T3_400m	306851,1	4990558	45,02869	14,04886
11.		PV_GET_1	307076,2	4989732	45,02133	14,05203
12.		PV_GET_2	307372,1	4989603	45,02025	14,05583
13.		PV_GET_3	307609,5	4989395	45,01844	14,05892
14.		PV_BLAZ_1	306242,7	4988129	45,00669	14,04208

Description of pilot site Raša

Site location is Crpna stanica Štalije upstream from mouth of river Raša. It is located on river Raša in Raša Bay. The river Raša is 23 km long, the river basin covers 279 km². It flows through the Raška Valley (12 km long, up to 1 km wide) and flows into the sea at Rasa Bay. From the overflow of the Rakonek spring to the mouth it is under the influence of the sea and shows salinity-dependent salinization. In rainy periods, the flow increases significantly, because in the middle part of the stream receives water from several abundant permanent springs (Bolobani, Sveti Anton, Šumber, Grdak, Rakonek, Mutvica, Kokoti and Fonte Gaja), occasional larger springs (Sušnica, Sušak) and several small unnamed occasional sources.

Raša Bay is situated on the eastern coast of Croatian Istria peninsula, southwest of the City of Labin. It is the lower part of the former valley of the river Raša, which is submerged by the young postglacial sea level rise. It is about 12 km long, with an average width of about 1 km. The depth of the bay varies from 44 m at the entrance to the bay to 10 m near the port of Bršica; further towards the mouth, shoals with depths of less than 3 m continue.

With its deposits, Raša gradually fills the bay, which is especially noticeable along the west coast. The sides of the Raša Bay are steep and inaccessible, built mostly of limestone, and overgrown with sparse Mediterranean vegetation.

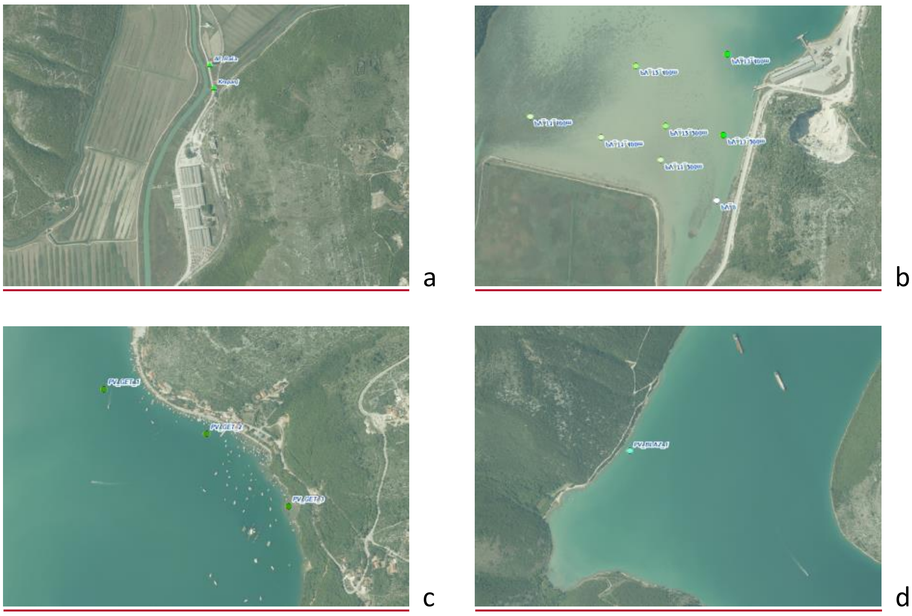


Figure 6.3 - 5 Location of the automatic sampling station (AP) at river Raša and channel Krapanj (a). Locations of measuring stations at Raša river mouth – transects (b). Locations of measuring stations at Raša bathing sea waters – GET 1, 2, 3 (c). Locations of measuring stations at Raša bathing sea waters – BLAZ 1 (d).

Description of Cetina pilot site

Site location is mouth of river Cetina, downstream part of the riverbed where two automatic sampling stations are positioned. The Cetina River is a typical karst watercourse in the deep and well-developed Dinaric karst. Cetina has a length of about 105 km, and it is the longest and most water-rich river in Dalmatia. Its basin covers an area of 1,463 km2. From its source in Dinara Mountain, at the height of 385 meters above sea level, Cetina flows into the Adriatic Sea in the town of Omis.

Figure 6.3 - 6 Locations of measuring stations at Cetina River mouth and bathing sea waters – transects (a). Locations of the automatic sampling stations (AP) at Cetina River (b). Locations of all measuring stations at Cetina pilot site (c).

Description of pilot site Neretva

Site location is mouth of river Neretva, downstream part of the riverbed (near the city of Ploče). The Neretva River basin is shared by Bosnia and Herzegovina (about 10,100 km2) and Croatia (about 280 km2). It is about 220 kilometers long, and only the final 20 kilometers are in Croatia forming an extensive delta with large reedbeds, lakes, wet meadows, lagoons, sandbanks, sandflats and saltmarshes. Neretva Delta is surrounded with karst hills rich with underground water that supplies numerous springs, streams, and lakes. The river mouth area is characterized with many drainage channels, and it represents ecologically unique area. In the Neretva Delta, at least 313 bird species have been registered. Neretva and its tributaries are also exceptionally rich in fish species. The Delta is the most fertile area of the middle Dalmatia oriented on commercial agricultural production (mostly tangerine plantations and vegetable greenhouses).

Figure 6.3 - 7 Locations of measuring stations at Neretva river mouth – transects (a). Locations of the automatic sampling stations (AP) at river Neretva and bathing sea waters (b). Locations of all measuring stations at Neretva pilot site (c).

Table 6.3 - 5 List of meteorological, physical, chemical, and microbial parameters analysed in river and seawater in Croatian target sites.

	Method (Manual, Automatic, Lab)	
PARAMETERS	**River**	**Seawater**
Physical chemical		
Air temperature (°C)	AS probe	CTD
Water temperature (°C)	AS probe	CTD
pH	AS probe	CTD
Redox (mV)	AS probe	CTD
Conductivity (mS/cm)	AS probe	CTD
Turbidity (NTU)	AS probe	CTD
Salinity (PSU)	AS probe	CTD
Oxygen saturation (%O_2)	AS probe	CTD
Dissolved O_2 (mg/L)	AS probe	CTD
BOD_5 (mg/L)	LAB	NO
COD_{Mn} (mg/L)	LAB	NO
Ammonium N-NH_4 (µM)	LAB	NO
TN (µM)	LAB	NO
TP (µM)	LAB	NO
Microbiological		
Escherichia coli (CFU/100 ml)	LAB	LAB
Fecal enterococci (CFU/100 ml)	LAB	LAB

Table 6.3 - 6 Sampling Strategy for Croatian sites.

No rainy events	4 samplings	One riverine water sample from the automatic sampling station. RAŠA: 2 monitoring stations. CETINA: 2 monitoring stations. NERETVA: 1 monitoring station.	Seawater samples. RAŠA: 12 monitoring stations CETINA: 6 monitoring stations NERETVA: 11 monitoring stations
Heavy rain events	6 samplings	14 riverine water samples from the automatic sampling station. RAŠA: automatic monitoring station (14 samples), and channel Krapanj (1 sample). CETINA: 2 automatic monitoring stations. NERETVA: 1 automatic monitoring station.	One seawater sample per stations. RAŠA: 12 automatic monitoring stations. CETINA: 6 automatic monitoring stations. NERETVA: 11 automatic monitoring stations.

6.4 Bibliography

- American Public Health Association, American Water Works Association, and Water Pollution Control Federation (APHA/ AWWA/WPCF,2017). Standard Methods for Water and Wastewater Treatment. (ed. 23th2540 D (2-70) (Washington).

- Davolio S., Stocchi P., Benetazzo A., Bohm E., Riminucci F., Ravaioli M., Li X.M., Carniel S. 2015. Exceptional Bora outbreak in winter 2012: validation and analysis of high-resolution atmospheric model simulations in the northern Adriatic area. Dynam Atmos Ocean. 71:1–20, doi: 10.1016/j.dynatmoce.2015.05.002.

- Ferrarin, C., Davolio, S., Bellafiore, D., Ghezzo, M., Maicu, F., Drofa, O., Umgiesser, G., Bajo, M., De Pascalis, F., Marguzzi, P., Zaggia, L., Lorenzetti, G., Manfè, G., and Mc Kiver, W., 2019. Cross-scale operational oceanography in the Adriatic Sea, J. Oper. Oceanogr., 12, 86–103, doi: 10.1080/1755876X.2019.1576275.

- Ferrarin C., Penna P., Penna A., Spada V., Ricci F., Bilić J., Krzelj M., Ordulj M., Šikoronja M., Đuračić I., Iagnemma L., Bućan M., Baldrighi E., Grilli F., Moro F., Casabianca S., Bolognini L., Marini M., 2021b. ***Modelling the quality of bathing waters in the Adriatic Sea***. Water 13, 1525. doi:10.3390/w13111525.

- Penna P., Baldrighi E., Betti M., Bolognini L., Campanelli A., Capellacci S., Casabianca S., Ferrarin C., Giuliani G., Grilli F., Intoccia M., Manini E., Moro F., Penna A., Ricci F., Marini M., 2021. ***Water quality integrated system: A strategic approach to improve bathing water management***. Journal of environmental management. DOI 10.1016/j.jenvman.2021.113099

- Umgiesser G., Ferrarin C., Cucco A., De Pascalis F., Bellafiore D., Ghezzo M., Bajo M. 2014. Comparative hydrodynamics of 10 Mediterranean lagoons by means of numerical modeling. J Geophys Res Oceans. 119(4), 2212–2226, doi: 10.1002/2013JC009512.

- Grafana Labs, 2020. The Analytics Platform for All Your Metrics accessed 14 March 2020. https://grafana.com/grafana/.

- National Oceanography Centre British Oceanographic Data Centre BODC https://www.bodc.ac.uk/

- SeaDataNet Ocean Data View (ODV) https://www.seadatanet.org/Software/ODV

- Cambpell Scientific. Datalogger support software (LoggerNET) Software https://www.campbellsci.com/loggernet

- EMODnet Bathymetry Consortium, 2020. EMODnet Digital Bathymetry (DTM 2020), doi: 10.12770/bb6a87dd-e579-4036-abe1-e649cea9881a.
- Strickland JDH, Parsons TR. A practical handbook of seawater analysis. J Fish Res Bd Canada. 1972;311 pp.
- Valderrama JC. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. Mar Chem. 1981; 10:109–122.
- Wikipedia, https://en.wikipedia.org/wiki/Iterative_and_incremental_development (accessed September, 28 2021).

6.5 Figures index

6.6 Tables index

7. MANAGEMENT MEASURES OF BATHING WATER

7.1 Current management

7.1.1 ITALY – Marche Region

7.1.1.1 Administrative procedures (public administrations, management bodies of the SSII)

Marche Region annually issues a Council Resolution to comply with the provisions of Article 4 of Legislative Decree no. 116/2008, entitled "Regional competences". In it, among other tasks, the Italian regions are responsible for:

a) identify bathing waters and monitoring points;

b) establish and update the bathing water profile, according to the indications provided in Annex III;

c) set up a monitoring program before the start of each bathing season;

d) classify the bathing waters referred to in Article 8;

e) extend or reduce the bathing season according to local needs or customs (this is a faculty that the regions have);

f) update the list of bathing waters;

g) carry out actions aimed at removing the causes of pollution and improving bathing water;

h) provide information to the public pursuant to article 15.

It is also recalled that information to the public is one of the most significant aspects of the legislation on bathing. In fact, both Article 12 of Community Directive 2006/7 / EC, and Article 15 of Legislative Decree no. 116/08, provide precise indications in this regard, encouraging and stimulating the use of "adequate means and communication technologies, including the Internet, to promptly promote and disseminate information on bathing water". To accomplish this task, the site of the Marche Region is useful, in which, in addition to the legislation and regional acts issued, it is possible to find the administrative procedures of the past and current bathing seasons and the site of the ARPA Marche, in which, in addition to an overview of bathing, complete with data regarding past seasons, there is also updated information in real time of the analytical data (conformity / non-conformity) of the bathing waters of the Marche Region, based on the monitoring calendar for the current bathing season. On this web page, also accessible from the regional site, it is possible to find the profile and the information board of each BW.

Entering into the specifics of the administrative procedures implemented in the Marche region, in the context of the management of the quality of bathing water, as regulated by the European directive and by the national transposition legislation, in the course of the last bathing seasons there has been more and more there is a clear need to standardize and simplify as much as possible the acts that are gradually issued by the bathing municipalities for the closure and reopening of bathing waters (BW), following events of a different nature.

The Union Orders (hereinafter UO, for the sake of brevity) applied in the territory of the Marche Region are both those provided for by current national legislation and those provided for at the regional level (the latter are underlined in the following list):

1. Initial UO or beginning of the bathing season must be prepared by the Municipalities that have, in their territory, bathing waters closed for bathing purposes for hygienic-sanitary protection (YP) and coastal stretches not used for bathing for safety reasons (because they overlook the mouths of rivers and streams and / or port / industrial structures);

2. <u>Management UO</u> (for seaside municipalities with the presence of urban wastewater overflows that lie directly on the coast or on waterways that flow into the sea after a few km) MUOs are aimed at managing events during which, due to heavy rainfalls, there are copious spills of urban wastewater (ARU) on one or more bathing waters, due to the activation of floodwaters present in the municipal area;

3. <u>Works UO</u> (for seaside municipalities, in whose territory the execution of non-extendable works is foreseen; it is a closure due to safety reasons and not pollution; the BWs affected by closure for works are in any case open only after compliant samples ARPAM, collected after communication of completion of work received by the Municipality);

4. Ordinary UO - BW closure are Union Orders for bathing waters (BW) closure issued following ARPAM sampling (routine calendar or additional) that had non-compliant analytical results;

5. Ordinary UO - BW reopening (to be issued following the restoration of conformity of the BWs due to the favourable outcome of the analyses on samples taken by ARPAM);

6. UO BW closure for algae or cyanobacteria bloom (following ARPAM communication): are Union Orders for bathing water (BW) closure due to samplings that have shown algal bloom (marine - coastal waters) or presence of cyanobacteria (lakes or artificial reservoirs);

7. UO BW reopening due to cessation of algae or cyanobacteria flowering (to be issued following the restoration of conformity of the BWs due to the favourable outcome of analyses on samples taken by ARPAM).

The administrative procedures relating to the closure of bathing water can be activated following water samples found not to comply with the legal limits, following reports of anomalous situations or as a precaution following urban wastewater leaks from overflows or from mouths of rivers or streams.

Marche Region has therefore prepared facsimiles of the Union Orders, to be used by seaside municipalities, also in order to facilitate the uploading of all the documents on the Ministry of Health Water Portal, an task that, from 2019 bathing season, falls to the Municipalities themselves.

The facsimiles were approved by Marche Region (Decree of the Manager of the P.F. Protection of Waters and Defense of the Soil and Coast n. 130 of 20 December 2019) and are closely related to the Resolution of the Regional Council, issued every year before bathing season beginning, because Union Orders have to follow the dictates and directions of the Resolution itself.

In addition to the administrative procedures, sampling activities are the main actions that make it possible to face bathing waters contamination.

In the annual Regional Council Resolution the criteria are established, according to which the waters must be sampled, in compliance with the rules issued by national legislation in force. Following these criteria, ARPA Marche prepares the sampling calendar and sends it to both the Marche Region and the Ministry of Health before the start of the bathing season.

The sampling calendar includes at least one monthly sampling (Legislative Decree No. 116/08 art.4, letter c), which must be carried out no later than 4 days from the date set by the same calendar, adequately and promptly justifying the change of date .

Annex IV of Legislative Decree no. 116/2008 provides that, shortly before the start of the bathing season, an additional sample is taken: generally ARPA Marche carries out this sampling in April.

With reference to the last flashing season, in the Marche Region the criteria adopted for the drafting of the definitive monitoring calendar were as follows:

• BW classified as excellent (1) or good (2) or sufficient (3) are monitored on a monthly basis;

• BW classified as poor (4) not permanently precluded (YP) or those still not classified (5, 6) are monitored on a fortnightly basis;

• BW permanently closed (YP) are monitored on a monthly basis. Even in the event of YP closure of the BWs, however, if non-compliant results arise from a routine sampling, the ARPAM must perform both the replacement and the supplementary samplings;

• the BW temporarily closed (YT) to bathing in the previous bathing season, which presented even a single exceeding of the limit values of the D.M. 30/03/2010 in the routine sampling, due to the introduction of untreated urban wastewater, if they are not in the conditions indicated in the following point e), they are carefully checked by ARPAM, also with additional sampling, with respect to meteoric events that they can create temporary alteration of the quality status (rivers, ditches…);

• in the BWs referred to in the previous point and in the BWs which, in the last bathing season, following the spill of urban wastewater (ARU) coming from the drainage systems of the sewerage networks, presented temporary closures (YTG) aimed at limiting exposure to the health risk of bathers with preventive actions, such as the adoption of the Management Union Ordinance (OSG), monthly routine sampling can be performed only if the adoption of the OSG is implemented and supported with the control of the effluent flow; if ARPAM deems it necessary to adopt a higher frequency as a measure for managing and protecting the health of bathers, sampling will be carried out at least every two weeks;

• all the BWs that presented temporary closures (YT) in the previous bathing season outside the cases presented in the previous points are checked according to the guidelines set out in point d); ARPAM can indicate higher sampling frequencies, possibly limiting them only to the periods of greatest tourist influx, in order to protect the health of bathers and reduce the risk of exposure to microbiological and pathogenic agents;

• the BWs that have submitted a downgrade are monitored on a fortnightly basis;

• ARPAM can indicate for any BW, regardless of the quality class, a fortnightly monitoring, where the potential risk of water contamination is identified, also on the basis of bathing water profiles;

• newly established bathing waters must be sampled every two weeks for the first two years, in order to define their first classification.

Furthermore, ARPAM intervenes with checks and analyzes even in case of reports of anomalous situations and in case of criticalities due to spills of drainage systems due to intense rainfall.

Various types of sampling and various situations for which BW closures occur are described below.

During **routine sampling** (i.e. those provided for by the ARPAM monitoring calendar), the limit values of one or more microbiological parameters may be exceeded. In that case, ARPAM immediately communicates the results to the Mayor of the municipality concerned and to the competent regional office, immediately initiating the necessary actions to:

• organize the sampling necessary to find the end of the polluting event;

• delimit the bathing water area to be precluded, if deemed necessary,

• determine the term of the polluting event and the restoration of compliance conditions in order to propose the lifting of the bathing ban;

in accordance with the provisions of Legislative Decree no. 116/2008 and by the Decree of 30 March 2010.

Short-term pollution is defined by Legislative Decree no. 116/2008, as:

"*D)" short-term pollution "means the microbiological contamination referred to in Annex I, column A, the causes of which are clearly identifiable and which is normally presumed not to affect the quality of bathing water for more than approximately 72 hours from the time of the first incidence and for which the competent authority has established procedures to predict and deal with such incidents as indicated in Annex II;* " - (article 2, paragraph 1, letter d).

For the management of short-term pollution, always referring to Legislative Decree no. 116/2008, we find in Annex IV the indication according to which:

"*4. In the event of short-term pollution, an additional sample is taken to confirm the conclusion of the event. This sample should not be part of the bathing water quality dataset. If it is necessary to replace a rejected sample, an additional sample must be taken 7 days after the conclusion of the short-term pollution*".

For the purposes of the assessment and classification of bathing water, the contents of paragraph c) of Annex II of Legislative Decree no. 116/2008, namely:

"*C) the number of samples discarded in accordance with Article 6, paragraph 6, due to short-term pollution during the last evaluation period represent no more than 15% of the total number of samples provided for in the monitoring schedules set for that period or no more than one champion per bathing season, being able to choose the largest*".

With reference to the samples that, due to force majeure, could not follow the monitoring calendar, it is confirmed that these samplings were carried out up to a maximum of 4 days from the set date (Article 6, paragraph 4 of Legislative Decree . no. 116/2008) and the reasons were:

• adverse weather and sea conditions that prevented the use of boats,

• possible and concrete risks for the safety of operators, due to organizational problems (inconveniences with the means made available by the Port Authorities).

At each sampling point, the water is sampled for bacteriological analysis in the laboratory (Escherichia coli and intestinal Enterococci) and in situ measurements of physical parameters (air temperature, water temperature, current wind, waves, etc.) are carried out.), as well as visual inspections (bituminous residues, glass, plastic, rubber, other waste).

If, on the occasion of a routine sampling (or provided for by the ARPAM sampling calendar), values of the microbiological parameters are obtained for a BW above the regulated limits and the relevant Municipality issues a trade union ordinance prohibiting bathing for this water, this could be reopened only if the supplementary sampling (PS), performed within 72 hours of routine sampling, shows the compliance of the parameters Escherichia coli and fecal Enterococci with the legal values. In this case, it would be Short Term Pollution STP (IBD or Short Term Pollution STP) and the non-compliant routine sample taken three days earlier can be replaced by a replacement sample (PT), to be performed within seven days of the supplementary PS.

The routine sample that presented non-compliance is replaced if and only if PT complies with the law and it is the PT values that will be part of the series of values useful for the classification of the BW for that bathing season.

In fact, the Legislative Decree no. 116/08 provides that:

"D)" short-term pollution "means the microbiological contamination referred to in Annex I, column A, the causes of which are clearly identifiable and which is normally presumed not to affect the quality of bathing water for more than approximately 72 hours from the time of the first incidence and for which the competent authority has established procedures to predict and deal with such incidents as indicated in Annex II; " (Article 2, paragraph 1, letter d));

"5. Samples taken during short-term pollution may not be taken into consideration for the purposes of the assessment referred to in Article 7 and are replaced by samples taken in accordance with the procedures set out in Annex IV. " (art. 6, c. 5);

"4. In the event of short-term pollution, an additional sample is taken to confirm the conclusion of the event. This sample should not be part of the bathing water quality dataset. If it is necessary to replace a discarded sample, an additional sample must be taken 7 days after the conclusion of the short-term pollution. " (Annex IV, point 4).

If the replacement sample (PT) is still non-compliant or the supplementary sample made within 72 hours (PS) does not comply with the legal limits for microbiological parameters, it will no longer be possible to speak of IBD, but will be configured as Long-Term Pollution (THE D). In this case, compliant results must be expected from samples taken as supplementary in order to reopen the BW.

The **additional samplings** on bathing water are always carried out by ARPAM, but are not part of the monitoring calendar that the Agency prepares before the start of the reference bathing season and uploaded to the Water Portal of the Ministry of Health.

The analyzes on the additional samples collected concern the same parameters investigated on the routine samples and are also aimed at the microbiological control of Escherichia coli and intestinal Enterococci for the verification of any exceeding of the limits established by law.

Additional samplings can be done for two main reasons:

1. following reports from different subjects (whether they are citizens or institutional bodies or subjects in any case interested in various ways in the protection of bathing water such as, for example, environmental associations), as a result of anomalous or dubious situations (smells or colors details of sea water, accidents, spills, and so on). In this case, the additional sampling is used to verify the presence or absence of an abnormal bacterial load exceeding the legal limits. The Municipality to which the BWs on which the additional sampling will be made belong may decide to close this area to bathing as a precaution, pending analytical results that confirm or deny the pollution;

2. after the closure of a BW, which occurred due to the activation of the Management Union Ordinance. In fact, when the floodwaters are activated due to heavy rains, the Municipality may decide to close the bathing area that is affected by the influx of spillways to bathing as a precaution. The reopening of this area can only be arranged downstream of additional samplings that are found to be compliant.

The following paragraph illustrates the current good practices envisaged in the Marche Region for the management of bathing water.

7.1.1.2 Good practice

There are various types of bathing water closures: the initials YP and YT refer to the Decree of 30 March 2010, in which, in Annex F, indications are given for the compilation of the bathing water reports to be drawn up at the end of each bathing season , so that they can be uploaded to the Ministry of Health's Water Portal, so that the latter, in turn, subsequently sends them to the European Community ("EU report").

In particular, in Table 1 of Annex F above, in the string "Closure", it is specified that the letter "Y" indicates that there has been a closure that has affected the specific bathing water, of which they are loading the data (the "Y" stands for "Yes").

A further specification was then required, indicating whether the closure was permanent (i.e. scheduled for the entire bathing season) or temporary (i.e. for defined periods of time within a season); a further letter has therefore been added to the code: YP = BW permanently closed; YT = BW closed Temporarily.

YP closures are defined directly by the law in force, which, in Article 10, paragraph 4, letter b) of Legislative Decree No. 116/08, provides:

a) (a) if bathing water is classified as 'poor' for five consecutive years, a permanent bathing ban is imposed. However, the regions and autonomous provinces can place a permanent ban on bathing before the expiry of the five-year period if they consider that achieving 'sufficient' quality is not feasible or is disproportionately expensive.

Therefore, the BW, for which the condition of YP exists, are already unambiguously indicated before the start of each bathing season in the Regional Council Resolution and are acknowledged and made active by every bathing municipality that is interested, as specified in the Union Ordinance of the Beginning of the Seaside Season, already mentioned.

YT closures are expected for different reasons, which can be caused by:

1. pollution detected during routine sampling, be it of short duration or not;

2. algal bloom that reaches emergency values. The closure is therefore identified with the acronym **YTA**;

3. extraordinary closure for works involving part of the coast, identified with the initials **YTL**.

In all three cases, the competent Municipality orders the closure of the BW for shorter or longer periods (with a specific Ordinance, which has already been mentioned in the previous paragraph) and every Resolution of the Marche Regional Council at the beginning of the bathing season reports the complete list of YT closures that took place in the bathing season preceding the one that is about to begin, specifying the nature of the temporary closures.

Finally, as already written in chapter 5, there are, along the Marche coast, situations of strong pressure on marine waters, due to the mouths of the rivers, streams and ditches that flow into the Adriatic Sea, which, in turn, receive water. wastewater from floodwaters that flow into these streams a few hundred meters upstream from their mouths. There are also urban wastewater spillways that introduce the wastewater they convey directly into marine waters, carrying their untreated load there.

This situation is mainly due to two causes: the first consists in the fact that, even if the water purification plants present in the Marche region discharge the water they purified into the watercourses that can receive them (both from the hydraulic point of view and from the chemical-physical one), strictly respecting the protocols and discharge limits provided for by the current sector legislation, however these systems must be equipped with by-pass or spillways which are activated in the event of intense weather events, which cause a hydraulic load not supported by the sewer network and the final plant; these spillways act in order not to create irreversible damage to the sewage system and to their infrastructures, but, by activating themselves, they bypass purification, discharging unsanified waste water into the sea.

The second cause of pollution is constituted by the spillways that directly discharge waste water not collected to the sewer network into the sea, because the agglomerations they serve have not yet been connected to the public sewer system and therefore do not provide for a dedicated purification.

Pending the adaptation of the existing sewerage and plant infrastructures and the construction of those that do not yet exist, to deal with these wastewater leaks into the sea, the Marche Region has proposed a mechanism for managing seawater subject to flooding, which various Municipalities they have willingly adopted, put into practice and tested them for several bathing seasons.

It is based on the precautionary principle, according to which it is necessary to protect the health of bathers and all the people who use the marine resource continuously, even in the period of time between the start of intense rain events (and the consequent activation of spillways and by-passes) and the analytical results on the samples taken by ARPAM.

If the management mechanism was not active, the ARPAM samplings would be performed only on the dates set by the calendar communicated by the Agency before the start of each bathing season and required by law (therefore every 30 or 15 days, depending on the BW to be sampled. and its criticalities), or following the reporting of anomalous events by citizens or entities (the latter sampling would be additional and would have an impromptu and unsystematic nature).

To cope with the aforementioned flood events, however, systematic samples are required, dictated by a codified method that guarantees the protection of bathing water users, precisely because the cause - effect mechanism (intense rain - flood) is now well established. known and potentially manageable.

Some seaside municipalities forced to manage these phenomena in the Marches have therefore resorted to the issuance, by the Mayor, of a particular act, called the Management Union Ordinance (for brevity OSG), which, issued before the start of the bathing season, immediately following the Initial Trade Union Ordinance (OSI), describes the procedures for closing and reopening the BWs subject to overflows of untreated urban wastewater following intense and / or prolonged rainfall.

In the description of the management methods of the overflows, all the subjects competent to conduct the events are listed punctually and what actions each of them must perform to control the closure and reopening of the BWs subject to spillage, thus configuring a synergistic chain of activities aimed at controlling the event in all its aspects and different moments, up to its end, which takes place with the reopening of the BW, always carried out downstream of the compliance results communicated by ARPAM and concerning the samples taken only after the end overflows.

The OSG also describes which are the contact persons to which each individual or entity concerned can have recourse to obtain information about the flood events (and therefore the closure and reopening of the BWs) both in terms of pollution and in terms of duration, precisely to promote information and public participation as much as possible.

The closure is of a managerial type (therefore not necessarily deriving from pollution, which could, paradoxically, also not exist, for particular situations of marine currents, dilution of pollutants and lower bacterial load) and is indicated with the acronym **YTG**.

The OSGs are aimed at managing events during which, due to heavy rainfalls, there are copious spills of urban wastewater (ARU) on one or more bathing waters, due to the activation of floodwaters present in the municipal area.

Municipalities interested in issuing these acts must send:

1. the Management Union Ordinance (OSG), issued before the start of the bathing season;

2. any letter of transmission of the deed.

Upon the occurrence of each event, in addition to the OSG, the following documents are sent by the competent subjects:

1. communication from the Managing Authority, in which the date and time of activation of the spillways are provided, with specification of the BWs affected by the spill (these communications can be sent directly by the Managing Authority or can be attached to the municipal communication of closure of the BW - not it is always present; sometimes it is only mentioned in communications from the Municipality or ARPAM);

2. communication from the Municipality, with which the BW affected by the spills are closed to bathing; this communication refers to its OSG and the communication of the Managing Body referred to in the previous point;

3. communication from the Managing Body indicating the date and time of deactivation of the overflows (it is not always present; sometimes it is only mentioned in the communications of the Municipality or ARPAM);

4. ARPAM communication, in which the conformity / non-conformity of the bathing waters affected by the floods is transmitted;

5. communication from the Municipality, with which the BW affected by the spills are reopened to bathing, referring to their OSG and the ARPAM compliance communication referred to in the previous point.

NB - It may happen that not all the BWs affected by the floods return to having compliant analytical results at the same time. Following the ARPAM communications referred to in point 3 (there may be more than one), the Municipality will gradually reopen the BWs, with its own communications referred to in point 4, only obviously when ARPAM establishes compliance.

7.1.2 ITALY – Abruzzo Region

7.1.2.1 Administrative procedures (public administrations, management bodies of the SSII)

The rules that regulate the quality of bathing water and the activities to protect the health of bathers are represented by the following decrees:

• Legislative Decree 30 May 2008, n. 116

on "Implementation of Directive 2006/77 / EC relating to the management of bathing water quality and repeal of Directive 76/160 / EEC", as amended by Legislative Decree 207 of 30 December 2008.

• Decree of 30 March 2010

containing "Definition of the criteria for determining the prohibition of bathing, as well as methods and technical specifications for the implementation of Legislative Decree 116/2008 implementing the Community Directive 2006/7 / EC, relating to the management of the quality of bathing water".

The aforementioned regulations have led to favoring an integrated management of water quality through actions represented by monitoring activities and the implementation of management measures, aimed at identifying and reducing the possible causes of pollution. Of great importance for the protection of public health is the classification of bathing waters and their area of influence from which the definition of "profiles", used for identifying the waters, derives. Profiles represent a fundamental tool for informing citizens about the quality of bathing water, the presence of risk factors for the health of bathers and any management measures adopted.

The Ministerial Decree of 19 April 2018, amending the Decree of 30 March 2010, in Art. 6 shows the obligation of the Municipalities to electronically transmit the prohibition and revocation measures of the bathing prohibition as soon as the communication from the technical structures responsible for sampling and analysis is received, through a specific function of the Water Portal of the Ministry of Health, according to the operating procedures defined with a joint provision of the general directorate for health prevention and the general directorate of digitization, the health information system and statistics of the Ministry of Health to be published on the institutional website of the aforementioned Ministry.

For the Abruzzo Region, the bathing water monitoring program is carried out according to the sampling schedule defined at the regional level, in agreement between the region itself and the Regional Agency for Environmental Protection, Arta. The dates are distributed throughout the bathing season with an interval that never exceeds a month; there is an additional sampling just before the start of each bathing season. The monitoring is normally carried out in the period April-September, unless a preventive derogation is made. Monitoring involves the microbiological analysis, the search for 2 parameters: Escherichia coli and intestinal Enterococci; these bacteria, as well as scientific evidence, are considered the best indicators of faecal contamination. At each sampling point, the survey of the meteo-marine parameters relating to the meteorological conditions and the state of the sea is foreseen.

In the Ministerial Decree March 30, 2010, for the purposes of bathing water for bathing, the limit values for each individual sample are defined, the exceeding of which determines the adoption of a temporary ban on bathing, through a trade union ordinance and information to bathers with suitable signs. The order is revoked following an initial favorable analytical result following the pollution event, which certifies the restoration of the quality of bathing water.

At the end of each year, considering the monitoring results of the current season and those of the three previous years, the waters are subject to evaluation and subsequent classification: each water is defined as "excellent", "good", "sufficient" or " poor ", based on the series of data relating to microbiological indices, Escherichia coli and intestinal Enterococci. Other parameters such as cyanobacteria, macro-algae, marine phytoplankton, monitored in waters with a potential tendency to their proliferation, as well as the presence of bituminous residues, and materials such as glass, plastic, rubber or other waste are not considered for the purpose of classification.

A provision of the European Directive 2006/7 / EC fully implemented in Legislative Decree 116/08 important for the protection of public health is that relating to the communication of information to citizens. In fact, the law provides for the transparency of the results of the checks to be guaranteed as much as possible by providing that all information relating to bathing water is easily accessible in the immediate vicinity of the same. The public must in fact be made aware, by means of suitable signs and in non-technical language, of the general state of the water based on the profile of the bathing water, of the classification and of any bathing prohibition. The local authorities, as far as they are concerned, encourage public participation by also allowing them to make suggestions, comments or complaints in particular for the updating of the bathing waters already identified. The Ministry of Health provides information to the public through its website on bathing data integrated with environmental data sent by the Regions. Finally, the bodies in charge, in compliance with the provisions of the law, using the most appropriate communication technologies are required to promptly disclose information on bathing water, especially for those classified as "scarce", and on short-term pollution events. During the bathing season, Arta guarantees information to the public by publishing an application updated in real time with the results of the analyzes on the Agency's website. The application also reports all information relating to the quality status and profiles of bathing water. The information and communication strategy, also regarding the possible presence of microalgal blooms with possible risk for bathers, is part of the tasks that ARTA Abruzzo must be able to ensure to citizens in order to achieve an increasingly effective method of managing possible environmental problems.

Each year, through the DGR, the extensions of the waters used for bathing and waters not used for bathing are indicated, the latter include the waters of the mouths of rivers and streams and port waters.

The municipal administrations collaborate in updating the Bathing Water Profiles, provided for in art. 9 of Legislative Decree no. 116/08, for subsequent inclusion by the Abruzzo Region in the Water Portal of the Ministry of Health and on the regional website.

7.1.2.2 Good practice

The Abruzzo Region has defined, in the annual bathing ordinance, starting from 2020, some effective procedures to allow better management of the theme of bathing subjected to the effects of deterioration in the quality of marine waters due to adverse weather phenomena.

For the purpose of reducing the timing and in accordance with the provisions of Article 3, paragraph 9, of Directive 2006/7 / EC, the subject of prohibition orders, checks and subsequent reopening measures, provides for the use of alternative microbiological methods for the analysis of bathing water, following a specific favorable opinion expressed by the Istituto Superiore di Sanità, on the possibility of using EN ISO 93082: 2012 and EN ISO 93083: 1998 as alternative analytical methods to those envisaged in the aforementioned European Directive for the monitoring of bathing water.

Other good practices implemented by the Abruzzo Region concern on the one hand the implementation of participatory processes and technical involvement and on the other hand the activation of thematic studies on sites of particular interest and complexity with the creation of specific working groups. Examples are

• the DGR n.301 of 21.04.2015, with which, in order to favor a preventive participatory process and the broadest involvement, two specific bodies were set up in the field of bathing water quality, the Regional Council and the Table Technician, based at the competent Maritime Works and Marine Waters Service of Pescara.

• the DGR n. 606 of 23/10/2019, with which a Working Group was established, a task force, with the aim of coordinating and monitoring all the interventions planned by the various subjects, relating to the Pescara River / Porto Canale / Costa Pescara system.

7.1.3 CROATIA

7.1.3.1 Administrative procedures (public administrations, management bodies of the SSII)

As previously mentioned in Chapter 4, regarding the Croatian legal framework on bathing water issues, the competencies of regional and local governments are determined by the national regulations. Hence, the local public authorities are in charge of:

- determination of bathing locations and monitoring of bathing waters in their jurisdiction,
- encouraging public participation in activities concerning bathing water quality assessment of the bathing locations and bathing season,
- informing the public on bathing water information during the bathing season.

Moreover, they are obliged to deliver bathing water quality and monitoring assessment to the Croatian Waters for each bathing water, in their jurisdiction, annually after the bathing season is over. Under Article 50, paragraph 6 and Article 252, paragraph 1 of the Water Act (OG 66/19), Croatian Waters monitor the condition of surface waters, including coastal waters and groundwater, about which they adopt a monitoring plan.

The monitoring, classification of bathing waters on surface waters, quality management of bathing waters and informing the public about the quality of bathing waters to preserve, protect and improve the quality of the environment and protecting human health is determined by Regulation on bathing water quality (OG 51/14). This regulation determines also the roles of regional and local public authorities in those issues. However, the Regulation excludes the transitional and coastal waters comprised by Regulation on sea bathing water quality (OG 73/08) and Regulation on water quality standard (OG 96/19). Since the WATERCARE project is mostly directed towards water quality in transitional and coastal waters the current management is further described from the view of the seawater quality.

Hence, considering sea bathing water, the regional public authorities (Counties) provide financial means for monitoring the sea bathing water quality, making cartographic representations of sea beaches and the development and renewal of the bathing sea profile. They also appoint the legal entities authorized for monitoring activities conditions in the field of environmental protection, according to the Environmental Protection Act and the Water Act, to perform the following tasks: sampling, monitoring of other seawater quality characteristics, laboratory analysis of samples, evaluation results obtained by sampling, produce reports and a profile of the sea bathing water. Such legal entities are authorized laboratories i.e. county institutes of public health of seven coastal counties. In the counties comprised by the WATERCARE project (SDC, DNC and IC) the authorized laboratories are *Split-Dalmatia County's Teaching Institute of Public Health, Dubrovnik-Neretva County's Public Health Institute* and *Istria County's Teaching Institute of Public Health*.

Moreover, the bathing season is defined as the period from June 1st to September 15th, if depending on weather and local customs, the representative body of the County does not decide that the bathing season lasts longer. Tracking sea bathing water quality is carried out from May 15 to September 30th. Hence, the responsible County is obliged to define sampling, testing, and monitoring points before each bathing season. Before the start of each bathing season, the authorized legal entity for performing sampling, monitoring and other activities, is obliged to prepare a testing calendar with the consent of the competent administrative body in the responsible County.

During the routine sampling, the limit values of microbiological parameters may be exceeded, meaning short-term or sudden pollution has occurred. In case of short-term pollution (marine pollution from a known source, recorded during regular sampling, i.e., contamination that is not expected to affect sea bathing water quality longer than 72 hours), the authorized entity immediately informs:

- the responsible administrative body in the county which is obliged to inform the public, the concessionaire and/or the local self-government unit using the media, with a warning about the occurrence and expected duration of the pollution
- the environmental protection inspector and other competent inspectors, according to special regulations (coordinated inspection supervision), to determine the source of pollution.

Data obtained in cases of short-term and sudden pollution at the first appearance are not added to the data sets for evaluation, by the provisions of Article 24 of Regulation 73/08. Upon termination of short-term contamination, authorized legal entities perform additional sampling within seven days. Samplings, for short-term pollution cessation checks and the obtained data, are then added to the data sets for grading quality. On the other hand, in cases of sudden pollution (occurrence of pollution upon notification) of the sea bathing water, the authorized legal entity (county institute of public health) is obliged, according to the notification on pollution, immediately perform sampling of the seawater, and submit the obtained data to the competent administrative County body and the Environmental Protection Inspectorate. The obtained data are not taken into account, i.e., they are not included in the set data when assessing sea bathing water quality.

The Environmental Inspection acts in cases of sudden, short-term and permanent pollution. If the short-term polluter is known, the environmental inspector orders it to take measures to eliminate the consequences of pollution. In case the contaminant is not known implementation of the pollution removal measure is ordered to the beach concessionaire or the local government unit. In case the sea bathing water quality does not correspond to the prescribed limit values, set out in Annex I, table 1 of Regulation 73/08, after removal of the source pollution and after the next regular sampling, the pollution is considered permanent. Thus, the environmental protection inspector orders a ban on swimming on the sea beach, placing an official swimming ban sign and setting up barriers on the land and sea part of the beach. However, if two in a row analysed seawater samples rated do not exceed the limit values of the Regulation, the environmental inspector issues approval to remove the official mark and barrier.

Once the sampling and testing are finished the authorized legal entities are obliged to deliver reports on the sea bathing water quality assessment to County. That comprises:

- data on single quality assessment deliver within seven days of the determined sea bathing water quality
- report on annual quality assessment within 30 days after the monitoring has ended i.e. until 5th of November of the current year at the latest.

Once the County receives the reports, they are obliged to upload them on their website and deliver them to the responsible ministry (Ministry of Economy and Sustainable Development). Moreover, the county is then responsible for making a report on the final quality assessment and further delivering it to the Ministry. Based on the reports collected from all coastal counties, the Ministry produces a *National report on annual and final seawater* *quality assessment on the beaches of the Croatian Adriatic Sea* (until 15th of December of the current year at the latest) which is later delivered to the European Commission.

The concessionaire of the beach and/or local public authority is obliged to display information boards on the sea beaches referred to in Article 7 of Regulation 73/08 with information on sea bathing water quality, general description of the sea bathing water, sea bathing water profile and information on possible emergencies on the sea beach.

As per Regulation 96/19, Article 29 the surface water monitoring (including transitional and coastal waters) is carried out by the water institute (Croatian Waters) according to the Monitoring plan adopted by Article 50, paragraph 6 of the Water Act and by the Monitoring Program adopted by the River Basin Management Plan referred to in Article 39 of the Water Act. The water quality testing is performed by the Main Water Management Laboratory of Croatian Waters, which according to Article 252 of the Water Act, is an official laboratory for sampling and analysis within monitoring and other official water controls. In addition to the Laboratory in the territory of the Republic of Croatia, water quality testing is performed by laboratories authorized for water sampling and testing. Laboratories that perform water sampling and testing must obtain decisions from the ministry responsible for water management, on the fulfilment of special conditions for performing the activity of water sampling and testing on indicators, group or groups of indicators, by the Regulation on special conditions for performing water sampling and testing activities (OG 3/20). Annexes of Regulation OG 96/19, among others, contain general normative definitions of categories of ecological condition for rivers, lakes, transitional and coastal waters as well as standards for the ecological and chemical quality assessment, classification schemes, lists of pollutants and others.

7.1.3.2 Good practice

In the Adriatic River basin district, there are 25 grouped transitional water bodies and 26 grouped coastal water bodies. By the Regulation on water quality standards in each water body, which is the basic unit of water management, it is needed to monitor and evaluate the chemical and ecological condition. As previously mentioned, the Monitoring is performed by the Croatian Waters. Two types of monitoring are conducted:

- Supervisory monitoring of the elements for the assessment of ecological and chemical status is carried out during one year within a carried out period of River Basin Management Plan or more often depending on the specific indicators
- Operational monitoring is carried out continuously, which means that the biological elements of quality are examined annually, every two or every three years, while physicochemical elements, specific pollutants and appropriate indicators of chemical status annually (six times a year).

When it comes to monitoring of the bathing waters, sampling and testing are determined according to the Regulation on bathing water quality (OG 51/14). Hence, one sample should be taken shortly before the start of each bathing season, and no later than 10 days before the start of the bathing season. Taking into account this additional sample and subject to point 2 of Annex IV, at least five samples should be taken and analysed in each bathing season. However, only three samples per bathing season should be taken and analysed if bathing water:

- has bathing season shorter than eight weeks, or
- is located in the area subjected to special geographical restrictions.

The sampling dates should be divided equally during the entire bathing season with spaces no longer than 30 days. Moreover, according to Regulation OG 51/14 bathing water can be classified as “unsatisfying”, “satisfying”, “good” and “excellent”. When bathing water is classified as “unsatisfying” for consecutive five years, the state water inspector introduces a permanent bathing ban or a permanent recommendation to avoid bathing. However, a permanent bathing ban or a permanent recommendation to avoid bathing may be introduced before the end of the five years if achieving "satisfying" quality is not possible or too expensive.

In water pollution caused due to wastewater overflows, there are measures prescribed by the Water Act and by the National Plan of Measures in case of Extraordinary and Sudden Water Pollution (OG 5/11). In the event of an unknown perpetrator of water pollution, the Croatian Waters Operational Plan of Measures in case of Extraordinary and Sudden Water Pollution is used.

Examples of good practices are not only those prescribed as legal actions in different events but also those developed for better management, improvement and promotion of the bathing water quality. Thus, as part of the implementation of the Regulation on sea bathing water quality (OG 96/19), the *Seawater Quality Database* has been developed. The database is used for input, processing and evaluating the results, informing the public and nationally reporting on the quality of the sea bathing water on the Croatian part of the Adriatic Sea and generating reporting bases for the needs of the European Environmental Agency (EEA). The Database Public Browser is customized to display standardized mobile device features. It is adapted to devices with smaller screens and automatic redirection is set, depending on the device type. Additionally, to the display of sea bathing water quality ratings, a display of all facilities on the sea beaches as well as active test points is also available. Moreover, it is possible to comment and suggest new test points via mobile device. Since most "smart" mobile devices have built-in GPS, which allows the geolocation of users, it is possible to find the nearest beach (which is included in the *Sea bathing water quality monitoring programme*) and distance displays (by air) to that beach.

To improve the sea bathing water quality at test points rated as “unsatisfying”, the annual assessment requires the connection of all entities to the public sewerage system, suitable drainage of rainwater without mixing with faecal wastewater and their relocation outside the zones of influence on the seawater quality, especially the on the sea beaches, maintenance impermeable septic tanks, construction of municipal wastewater drainage systems in settlements without sewerage, appropriate treatment and direction of treated wastewater, as well as maintenance of the public sewerage system.

Curiosity

The Republic of Croatia and the Italian Republic participate in the Blue flag programme that is the most recognized model of environmental education and public information, when it comes to caring for the sea and the coastal areas, and especially when it comes to caring for coastal areas that suffer the most pressures as beaches and marinas. The Blue flag is an international ecological programme for the protection of the marine and coastal environment, whose primary goal is the sustainable management and governance of the sea and coastal areas. This is also a very esteemed touristic stamp that marks the quality of the sea i.e. beach. So far, the Programme participates over 46 states throughout the world and over 4,400 Bule flags have been assigned.

7.2 Future management using the Alert Tool

7.2.1 ITALY – Marche Region

7.2.1.1 Alert Tool

The Alert Tool system makes it possible to highlight critical situations, which can arise during adverse weather conditions.

The FOM forecasting model, described in chapter 6.2.3, allows a daily numerical integration of weather data, which produces a two-day forecast response of potential rain falls.

These assessments can allow the definition of potential scenarios, which detect any critical situations with respect to microbiological contamination, which can arise as a result of the introduction of quantities of urban and meteoric wastewater, coming from the inputs of sewerage systems and courses of natural water, into which these inputs are introduced.

In practice, the WIQS system, integrated with the FOM, describes the evolution of microbiological contamination, which can occur following the introduction of urban wastewater, describing the scenarios that can be determined in the observed bathing site.

The representation of critical scenarios, for the purposes of spatial diffusion and temporal permanence in the site, through real data, detected by the WQIS system and developed according to the characteristics of the site, helps the technical-administrative decision-makers in adopting health protection measures towards bathers, who are the potential exposed subjects.

These scenarios can be determined from the data collected directly by the system, or, alternatively, from specially created scenarios, which indicate the most impactful and critical rainfall conditions for the bathing site.

The Alert determined by the system favors preventive management: by adopting the measures described in paragraph 7.1.1. and through predictive scenarios and the analysis of weather data in real time, it should suggest the area of diffusion of the contamination and its duration according to the marine weather conditions that are occurring.

7.2.1.2 Administrative procedures (public administrations, management bodies of the SSII)

The procedures that will be adopted by the public administrations, in the Italian case, are those relating to the issuing of the Trade Union Management Ordinances (OSG), described in paragraph 7.1.1 and introduced by the Marche Region, to anticipate the ban on bathing, when pluviometric weather conditions, which determine the drainage of the sewer networks.

Therefore, these administrative actions, which already have good effectiveness, will not be changed in adopting preventive and useful actions for the health protection of bathers.

These procedures may be associated with the sampling of bathing waters, for the verification of the restored compliance, or with predictive scenarios, developed by the FOM, if the model provides predictive scenarios similar to the microbiological tests carried out in the field.

To date, it is necessary to ensure, for the implementation of the data in support of the FOM, an adequate numerical series of data, until the objective is achieved, i.e. when the predictive scenarios of the model are highly consistent with the data. monitored in the field.

Only at this point, with the consistency between predictive assessments and microbiological analyzes carried out during the rain and contamination event, the two options can be adopted in a complementary way and will be able to guarantee the protection required by the regulations.

7.2.1.3 Good practice

The good practices to be adopted are to be developed on three levels, which mainly implement the knowledge to allow the best application of the Alert Tool:

- all the characteristics of the site (geographical, territorial, with attention to urban developments, the construction of marine defense works to combat erosion, weather-climatic trends) must be constantly updated, to allow the predictive system to better elaborate the scenarios forecasting;

- the frequency and occurrence of microbiological contamination phenomena and the assessment of its spatial diffusion and temporal duration are characteristics that specifically define each site; for this, continuous action is required, including environmental monitoring, of bathing water with respect to the impacts that are generated;

- a detailed knowledge of the infrastructures and their functioning, on the occasion of rain events, which determine criticalities in the bathing waters of the site that is subjected to microbiological contamination.

The latter is fundamental, as the network of sewer pipes, based on the presence of overflows along the network, determines the condition, for which the flooded waters can have more or less impact; the knowledge of the loads, which can escape from the overflows, makes it possible to evaluate the extent of the spread of contamination and, based on the weather and sea conditions, those of persistence in bathing waters.

Shared protocols between management actors and public administrations facilitate the organization and implementation of the necessary management measures.

7.2.2 ITALY – Abruzzo Region

7.2.2.1 Alert Tool

The methodology and instrumentation installed for the implementation of the activities envisaged by the Watercare project, combined with the empirical results of implementation, allows us to anticipate the maintenance of the apparatus beyond the project itself.

The importance of predicting and temporally quantifying the effects on bathing of changes in the water quality of the Pescara river introduces the topic of targeted management of prohibitions and control activities. The simulation carried out by the Watercare project describes the current port configuration of the mouth and will allow to develop, starting from the continuous analytical data, the alert limits and thresholds and the related protocols to be implemented by the subjects responsible for the sanitary surveillance of the waters of bathing of the coast north and south of the point where the river enters the sea.

The creation of a protocol, with promoters from the Municipality of Pescara, the Abruzzo Region and ARTA is already a matter of institutional discussion. Both a simplification in the proposition of bathing bans following summer rainfall and a targeted description of the times and areas of evidence of the effects on the quality of marine waters are being envisaged. This regulatory apparatus is based on a predictive and continuous reading system of the data that will necessarily be able and must use the methodologies, models and site-specific data defined by the Watercare project for the Pescara site.

Naturally, the model will be updated to the new conformation works of the canal port, which provide for the lengthening of the docks beyond the breakwater, in order to keep the predictive feedback of the system updated and effective.

7.2.2.2 Administrative procedures (public administrations, management bodies of the SSII)

The complex system of the quality of marine bathing waters, combined with that of the river waters at the mouth of the Pescara river, places various bodies around a single protocol which, due to their functions and responsibilities, have to carry out management and control activities.

The Abruzzo Region has its own functions related to the regulation of bathing, water protection and therefore the authorization of unloading activities in the Pescara riverbed.

ARTA is entrusted, by the regional health department, with sampling and analysis activities during the bathing season (according to the monitoring calendar) and analysis for the purpose of verifying the restored bathing conditions following exceeding the threshold values.

The ACA is the entity, actuator of the integrated water service, which manages both the Pescara purification plant (Via Raiale), and the overflows and overflows of the city sewage system.

The municipality of Pescara is responsible for the implementation of the bathing ordinance and orders the prohibitions and prohibitions in compliance with Legislative Decree n. 116/08, also monitoring the malfunctioning of the drains in the riverbed.

The four institutions involved had already collaborated, prior to the Watercare project, producing a specific management protocol for the system within the authorization for the discharge of the purifier and the first rain tanks (DPC024 / 062/2018). This system currently manages the alert only in terms of Event Communication - General Prohibition - Control cases. The implementation of the Alert system with modeling and the Watercare system will allow a more selective case of prohibition with a consequent lower negative effect on the tourist-accommodation system and on the timing and control activities for the verification of the restored health conditions.

The system envisaged by the Watercare project will allow for a refinement of this protocol and the integration of the communication procedures of the quantities spilled with the quality of the water recorded by the automatic sampler installed by ACA as part of the project. Watercare's activities are a particularly incisive starting point for the development of the manager's self-control times and emergency measures in the event of unforeseen accidental events, such as breakdowns or malfunctions.

7.2.2.3 Good practice

With reference to the bathing ordinance, which records the protocol described above, in the event of heavy rains and / or failure of the purification plants or collection systems, with activation of the flood spouts and relative spillage of untreated wastewater into seawater, reported in real time by the managing body of the water system, the management measures indicated in Annex "D" of DGR 241/2021 are activated, which provide for the issuance by the competent authority (Municipality of Pescara) , of a temporary ban on bathing in the section concerned. The event must be promptly reported to the Abruzzo Art, which will carry out the control analyzes at the end of the episode, for the purpose of lifting the ban.

Furthermore, with reference to the provisions of art. 10 of the Legislative Decree. n. 116/08 and in order to make the aforementioned management measures more effective and participatory in the event of meteorological events that determine negative impacts on the quality of bathing water, the Municipality of Pescara is given the opportunity to propose Operational Management Protocols, to be shared with all '' within the Regional Technical Table, established with DGR n.301 of 21.04.2015, which, with reference to the relations and interference between the purification system and the quality of bathing water, define further general reference frameworks, for the roles of the subjects interested parties and for the measures to be taken on the occasion of the events and the necessary actions to protect public health.

7.2.3 CROATIA

7.2.3.1 Alert Tool

A real-time alert tool that predicts potential ecological risks related to the bacterial contamination of bathing water after extreme raining events connected to the forecast operational model is an integral part of the WQIS system installed in all pilot sites on the Croatian side of the Adriatic Sea.

The alert tool interconnects different actors in the water management value chain through the communication channel. The data acquired on the rainfall, power failure, sampling cycle, CSO and FOM result were sent to the responsible recipient through different notification channels (depending on whether it is alert on sampling procedures or hardware management). This system of a real-time alerting system enables decision-makers on all levels to make timely and necessary decisions in the area of bathing water control.

The alerts that the tool provided regarding system progress, abnormalities in the environmental parameters and hardware within the project can reach far beyond the scope of the WATERCARE pilot sites. Considering there are many monitoring and sampling points of the bathing waters, on the Croatian side of the Adriatic Sea that are tested annually before the bathing season, the duration of those activities prolongs even when the season starts. In such events, the microbiological values of the waters can be exceeded but people have already used it for bathing. For example, on the mouth of the Raša, Cetina and Neretva. This is the point where the alert tool can make difference in the future management of the bathing waters. If installed on targeted critical points, e.g. mouths of rivers in which are discharged wastewater, coastal waters in the proximity of industrial facilities, the alerting system will inform the relevant authority body on the status of the waters and whether a ban on bathing is necessary and thus preventatively act towards protection of public health.

7.2.3.2 Administrative procedures (public administrations, management bodies of the SSII)

The water management regarding the bathing waters and its quality is a complex system that involves several actors on different levels of authority. Hence, in the pilot sites observed on the Croatian side, the system involves:

- Local municipalities that are under the impact of the rivers Cetina, Neretva and Raša
- Regional public authorities i.e. counties of Split-Dalmatia, Dubrovnik-Neretva and Istria that provide the financial means for monitoring the sea bathing water quality, making cartographic representations of sea beaches and the development and renewal of the bathing sea profile
- Croatian Waters as an executive body for water management in the Republic of Croatia
- Authorized laboratories i.e. county institutes of public health (Split-Dalmatia County's Teaching Institute of Public Health, Dubrovnik-Neretva County's Public Health Institute and Istria County's Teaching Institute of Public Health) that perform the sampling and quality monitoring activities.

Moreover, in the cases of pollution acts the Environmental Protection Inspectorate. The mentioned institutions already collaborate to provide quality water management specifically concerning bathing waters and the protection of human health. The implementation of the WQIS system with the Alert tool will enable real-time information on the status of the bathing water and the timely reaction of the responsible authorities in the cases of pollution. Moreover, it will improve the interaction between the aforementioned authorities and ensure a high level of protection of public health and eliminate possible negative effects on tourism due to swimming bans.

7.2.3.3 Good practice

As part of the Watercare project, Split-Dalmatia County has developed an application WaterCare with the basic goal of improving environmental quality conditions at sea and in coastal areas. The application is an innovative tool in water management and treatment, i.e., improves microbiological, environmental and, resource efficiency in bathing and coastal waters.

The application is in line with the Water Framework Directive (WFD) as it affects:

- assessment of microbiological contamination related to the assignment of environmental status and natural variability (meteorological conditions)
- it is an integrated water quality control system that connects the conditions and environmental effects of wastewater spills.

Also, the application is characterized by GIS functionality, register of locations and, presentation of water quality parameters. GIS functionality is implemented through a cartographic system that shows the locations monitored within the project. The site registry has a separate database for managing and storing data on each site, so the application can also support adding sites that are not covered by the project.

Given that the specific display of data is only available to users who verify their identity through a username and password, we can conclude that it is a great help tool for decision-makers. A certain display of data is publicly available to all users, without the need for identification, so it is also useful for the population in selected locations.

8. INTERVENTION PROPOSALS ON WATER INFRASTRUCTURES

8.1 ITALY - Marche Region

The existence of "mixed" sewage networks (ie those networks within which in dry weather only the waste water is conveyed while during meteoric events, rainwater and run-off are also added to the latter) can generate serious problems of localized pollution in the receptors of any overflow or overflow flows coming from the overflow structures that may be present in the line.

The overflow artifacts (CSO - Combined Sewer Overflow) have the purpose of limiting the flow of volumes into the network with the aim of protecting the networks themselves from overflow phenomena or the final treatment plants ensuring compliance with their maximum capacity. The negative side consists in the discharge in general of the excess flow rates into the environment which, in fact, can generate considerable pollution phenomena, often of short duration in the receiving bodies.

In the current paragraph, a series of characteristic interventions are proposed, with the aim of mitigating or canceling the phenomena of contamination of bathing water through the spills of diluted wastewater during intense meteorological events.

For each of the proposed interventions, a general description of the identified technical solution, the peculiar characteristics, a comparison between the advantages and disadvantages of the solution and any relevant notes will be provided. For the detailed analysis of each of the proposed technical solutions and for further notions concerning the applicability, operation and sizing criteria, please refer to the dedicated document called "D.4.3.1 - Guidelines to assess the quality of urban wastewater and coastal system" produced by the leader of the Work Package nr. 4.

8.1.1 First rain tanks

A first possible solution, applicable downstream of the overflow artefacts (CSO) consists in the accumulation, located in special tanks, of the overflow flows (in general, a quantity of wastewater corresponding to the first 2.5 - 5 mm of rain fallen on the reference basin), avoiding its dispersion into the environment and postponing delivery to the existing final treatment plant with respect to the meteoric event, through a special pumping system that limits the flow rates.

The system, which coincides with that created by Aset SpA (WP4 leader) in the pilot plant in the city of Fano (Italy) near the mouth of the Arzilla stream, therefore provides that all the volumes that do not exceed the tank capacity, are conveyed starting from the drainage products (CSO) in this large container through a dedicated piping system.

The artefact consists of a waterproofed reinforced concrete tank of considerable size, usually equipped with electromechanical equipment such as pumping systems, gates and automatic cleaning systems for better maintenance. Usually these large containers are built underground both for functional reasons and to eliminate their visual impact.

It is clear that the great advantage of this solution consists in the zeroing of the volumes discharged into the environment with tangible positive consequences for the surrounding eco-system, as long as the volumes flowing from the CSOs do not exceed the maximum accumulable volume. The amount of rainwater drained and conveyed into the first rain tanks usually collect a significant part of pollutants deposited on the roadway or within the sewer system itself. Any spillage of the excess portion into the environment would be linked to phenomena with exceptional return times and in any case highly diluted with tangible effects on the environment.

The main disadvantage can be represented by the high construction and maintenance costs, as well as by the executive difficulties in finding spaces, both for the considerable dimensions and for the construction of the areas, especially in historically and highly urbanized contexts, in which it is very often probable to find "mixed" sewage systems.

Another tangible disadvantage is the increase in operating costs related to the transfer of the accumulated flow rates and the subsequent treatment of the same (energy costs, maintenance costs, treatment difficulties given the high dilution of the wastewater).

We can also mention the buffer tanks, hydraulic artefacts aimed at the partialization of the mixed flows deriving from intense meteoric events. If suitably sized and designed, they can also fulfill the purpose of first rain tanks at the same time.

8.1.2 Off cliffs collectors

A second possible solution, applicable downstream of the overflow structures (CSO) present close to the coastal areas, consists in the construction of subsea pipelines of such length as to overcome the bathing strip, especially the breakwater barriers that can make bathing waters confined, and discharge the excess flow rates to a depth that guarantees a dilution process of the concentrations of Escherichia Coli and Intestinal Enterococci below the parameters required by the bathing legislation, since the initial dilution and the regime of the waves and currents that determine the dispersion of the plume, created on the surface, depend on the depth.

Usually, the works to be carried out consist in the construction of special channels (of extremely variable extension from a few tens of meters to a few kilometers depending on the number of CSO flood artifacts involved) for the collection and conveyance of the drainage waters in a special pumping drainage station. From this point, high-capacity electro-mechanical organs push the diluted wastewater at a distance through pipes of large diameter suitably anchored or ballasted on the seabed.

Depending on the flow rates involved and the extension of the intervention basin, further works with the function of laminating the peaks could be planned and further tanks could be provided for the separation of the first rains in order to achieve more effectively the environmental protection objectives.

The most relevant aspects often concern the construction of subsea pipelines which can be made of self-sinking material or floating plastic material and subsequently covered with sand and geo-fabric bags and equipped with ballast products against the action of waves and buoyancy thrusts in case of empty pipeline.

The environmental and economic benefits of the proposed intervention are significant both for bathing and for the quality of the sediments and shore waters where in the pre-project condition the waste water from the overflows is discharged.

Submarine pipelines also have high installation costs and certainly maintenance costs higher than those required, for example, for first rain tanks. The comparison between the two alternatives, which does not exclude mixed solutions, cannot however be theoretical and must be evaluated in real cases, in specific situations, where the boundary conditions can have a significant weight on costs and results.

8.1.3 Overflow water treatment

An alternative solution that can always be applied downstream of overflow structures (CSO) for the management of overflow waters is their continuous treatment on site, both through static products and through electromechanical equipment or natural systems.

The on-site treatment of overflow waters, although less stringent than that which could be carried out in a purification plant, is in many cases suitable for overflow waters, which are generally characterized by a lower polluting load than waste water. In addition, in situ management allows the treated water to be returned to the surface receptor, instead of having to reintroduce it into the sewer system.

The choice of the optimal type of treatment depends on the quality of the water and the pollutants present, as well as on the purification needs linked to the final receptor.

Among the most widespread and most applicable technological treatments, the following solutions are mentioned:

- Static sedimentation
- Grilling and micro-grilling
- Oil removal / sand removal
- Mechanical filtration

As for the natural type treatment systems, those most experimented and studied at an international level are classified according to the type of "macrophytic" plants used (floating, rooted submerged, rooted emerging) or more often based on the path water plumber. The natural treatment systems analyzed in the document "*D.4.3.1 - Guidelines to assess the quality of urban wastewater and coastal system*" are:

- Free Water Surface – FWS
- Horizontal flow systems – HF
- Vertical flow systems - VF

The treatment of overflow waters has some specific peculiarities that affect both its efficiency and the field of application / use:

- extreme variability of the flow rates;
- extreme variability of polluting loads;
- higher flow rates than those to be treated in the case of waste water plants;
- periods of inactivity;
- plants generally less manned than a waste water plant;
- large surfaces involved;
- possible incompatibility with urban planning plans for built-up areas.

These characteristics obviously have a weight in the diffusion and in the field of use of the different treatments and in the definition of possible treatment schemes and therefore significantly affect their applicability, in the face of the complete sustainability of the intervention, especially thinking about natural treatment systems.

8.1.4 Sewer networks splitting

The separation of the meteoric networks from those of waste water can be classified as an intervention to be carried out "upstream" of the overflow structures and allows to reduce or even eliminate the need for CSO and related discharges.

This type of solution can be feasible and advantageous in particular in the presence of some conditions:

• implementation on new urbanizations or in any case in non-densely urbanized areas where separation is physically possible;

• presence of receptors for the discharge of rainwater, without these all having to be conveyed towards the delivery of the wastewater network;

• availability of space for the installation of the dual network without interference between the relative connections;

• concomitance with other works on road pavements or on the existing network that make the separation intervention convenient;

• reduced slopes available and difficulties in discharging into the surface receptors, which make the separation of the networks convenient: installation of booster systems for the black network only, characterized by lower and more constant flow rates, independent management of rainwater.

Operationally, the conversion of a mixed network into a dual network can take place through the construction of a new meteoric network, keeping the existing one for black water only or vice versa.

If the mixed network presents problems of hydraulic insufficiency, the first option may be convenient, by designing a second network suitable for collecting only rainwater and instead dedicating the existing network to black water only.

This choice has the advantage of not requiring interventions to move the existing wastewater connections, but only the drains and other elements of rainwater drainage, with less need for the involvement of citizens. In the event of deteriorated networks, it may be appropriate to envisage remediation interventions aimed at avoiding the infiltration of waste water into the soil.

If, on the other hand, the existing network does not present problems of hydraulic insufficiency with respect to the project meteoric flow, it can be envisaged to convert it to a meteoric network, creating a new network, smaller in size, but with sufficient slopes to avoid deposit phenomena, for the only waste water. This choice entails the need to intervene on all waste water connections. In this case it is always advisable to provide checks and monitoring downstream of the intervention to verify that there are no unconscious black water connections left, which at this point would be discharged directly into the final receptor.

In evaluating this type of intervention, beyond the implementation difficulties and costs, it is good to take into account some factors that may limit its effectiveness.

In the first place, the rainwater deriving from the washout of surfaces, in particular those from roads or production areas, can contain a significant polluting load.

It is therefore necessary to provide for the management of rainwater with continuous accumulation or treatment systems.

Finally, in the presence of separate networks there is always the risk of irregular connections of rainwater to the black network, with the risk of overload, or of waste water to the white network, with consequent direct discharge into the environment.

The activity of splitting the networks ideally represents an excellent project even if, as we have seen, the environmental benefit is not immediately achievable, given the problems of heavy pollution of the first rains and the possible uncertainties related to the need to promptly investigate all the sewer system affected. It is therefore not always true in an absolute sense that this approach can be 100% definitive: therefore important evaluations are necessary, always aiming for effective and sustainable solutions.

8.1.5 Best practice

The solutions just proposed, as highlighted, are applied exclusively downstream or upstream of the overflow structures. These interventions can and must be seen in an integrated manner, with an approach that aims to mitigate the "upstream" pollution phenomena, reducing the contamination of rainwater drainage, both through the separation of the networks and through the reduction of the contribution of rainwater in the network, using sustainable drainage solutions.

Although these are solutions that can hardly be extended to the entire basin, especially in already urbanized contexts, these interventions have the advantage of being able to be implemented gradually as part of a more general planning relating to urban water management.

An approach is therefore envisaged for solving the problems of pollution of the water of the receptors distributed along the time scale, locating, immediately, interventions of certain efficacy to be carried out downstream of the CSOs, thus avoiding contact between the diluted wastewater and bathing waters and, in subsequent phases, interventions aimed at improving the quality of drainage water and at the same time reducing the influx of meteoric nature.

The latter are the first concepts of sustainable urban drainage (SuDS - Sustainable Drainage Systems), which aims to manage rainwater falling in urban areas in order to:

- rebalance the hydrological balance and reduce the polluting load towards the water bodies, recreating the conditions existing on the territory before urbanization;
- build green infrastructures capable of exploiting all the benefits provided by the ecosystem services of natural solutions (Nature-Based Solutions).

Sustainable urban drainage techniques provide various ecosystem services, in addition to improving water quality by intercepting the most polluted part linked to the first rain and reducing water peaks and consequently reducing the activation frequencies of mixed sewer overflows:

- atmospheric regulation

- climatic regulation
- water regulation
- water recovery
- erosion control and sediment retention
- soil formation
- balancing nutrient cycles
- reduction of pollutant load by exploiting natural processes
- pollination
- increase in biodiversity
- biomass production
- increase in recreational areas
- environmental education.

The approach through sustainable urban drainage systems SuDS can be applied to different contexts, from individual homes to an entire urban and sub-urban area, with different levels of naturalness and ecosystem services offered.

8.2 ITALY - Abruzzo Region

For Pescara site, the issue of infrastructural equipment aimed at resolving the effects caused by the overflow of rainwater directly in the riverbed during intense meteorological events, was addressed by Abruzzo Region through the forecasting and financing of the construction of a collection of first rain water, and its collection at the purifier near the site, upstream of the installation point of the automatic sampler for the surveys and monitoring envisaged for the Watercare project.

The construction of first rain tanks allows the correct collection of the waters coming from the Riviera.

These endowments will be added to the modifications foreseen for the mouth system by the Port Regulatory Plan approved in 2009, with the financing of the extension of the two piers. This new configuration allows the river to flow into the coastal marine waters beyond the breakwater and the barriers placed in front of the stretch north of the mouth of Pescara river.

Obviously, these solutions, of high investment, propose an effective solution scheme that will eliminate the negative contributions to the quality of bathing water.

The instruments foreseen in the Watercare project will be implemented to be useful for the monitoring and management of the planned infrastructures, and in particular of the first rain tank.

The issue of monitoring the quality of the waters along the estuary still remains to be addressed as regards the upstream spillways, especially through more stringent legislation on the parameters to be assessed, the methods of water treatment and the control of the quantity of these ones that convey to the final stretch of the river.

The system is made more efficient by the creation of a dual sewer network to be built on the occasion of the completion and modernization of the urban waste collection network of the city of Pescara.

8.3 CROATIA

Multi-year program for the construction of communal water construction for the period until 2030 (OG 117/15) envisages investments in the development of the public sewerage system in Croatia. Investments are mostly directed to agglomerations with the aim of construction of wastewater treatment plants concerning the minimum required level of treatment and the development of municipal wastewater collection systems. A general characteristic of the Croatian water utility sector is the large gap in the development of drainage services with water supply. Only 43.6% of the population is connected to the public sewerage system, with large differences between regions, counties, municipalities, and cities. About 100 water treatment plants were built, and the wastewater treatment service covered 27% of the population or 61% of the population connected to the public sewerage system. The largest share of wastewater refers to wastewater from households (about 60%). One-third of the total collected wastewater is discharged into the environment without treatment, while the remaining two-thirds are treated in one of the existing devices. Hence, several objectives on water-utility infrastructure concern infrastructural improvements. Such as achieving a higher level of connection to the public sewerage system, achieving greater harmonization about the level of municipal wastewater treatment, achieving a higher level of harmonization of individual drainage systems in agglomerations and reduction of water load by discharging untreated or insufficiently treated municipal wastewater priority on those water bodies where the objectives for water protection have not been met.

Although is constantly being invested in the reconstruction of water and communal infrastructure in Croatia and efforts are being made to modernize it, there are still frequent problems with water supply, pipe bursts, and large water losses, as well as wastewater and sewage spills. Since in Croatia prevails a mixed drainage system that is drained into the sea, the coastal areas are at threat of pollution due to wastewater spillage. This specifically is threatening to the coastal bathing areas. Even though the drainage system is overall good, excessive rainfall and insufficient reception capacity of the existing drainage system often cause wastewater overflow and pollution of the recipient waters consequently bathing waters. Also, it is very common that parts of the pipes, that drain wastewater into the sea, begin to leak before the place of intended discharge. Under the influence of sea currents, wastewater very easily ends up in bathing places and pollution can lead to infection of the population. It is for such reasons that it is necessary to work on systems for the renewal and modernization of existing infrastructure as well as the introduction of new and innovative systems and methods of wastewater collection and treatment to reduce the likelihood of pollution. In the context of improving services and reducing the likelihood of bathing water pollution, local administrations in the project pilot areas can make several infrastructural improvements.

Improvements are primarily related to the construction, maintenance and improvement of water supply and drainage systems through the application of modern technologies. In the context of efficient and sustainable maintenance and modernization of the water supply and drainage system, there are several solutions whose implementation improves the entire water utility system. Given that most water utilities do not have a fully developed system of planning and preventive maintenance that would timely identify the necessary activities for system maintenance and prevent adverse events due to deteriorating infrastructure, it is necessary to develop a system of activities to measure the frequency of such events. Such a system will enable greater efficiency of the water supply and sewerage system, improve the services of administrative bodies and increase the safety of the population and reduce the possibility of pollution. For system purposes, it is possible to introduce a digital and automated maintenance system as a tool for planning preventive and corrective maintenance. This enables regular maintenance planning and provides a basis for planning preventive activities that are not currently carried out in most administrative bodies. The existence of such a system would enable integration with the storage system, which would consequently receive timely information on the procurement of the necessary equipment and spare parts needed for maintenance. It would also facilitate the establishment of cooperation with stakeholders from other sectors with which certain types of work are carried out on water supply and drainage systems. To establish the system, it is necessary to make a comprehensive analysis of the current state of equipment and infrastructure to get a clear picture of the required work and installation time. Currently, in Croatia, there is no GIS platform for most water utility systems on which it is possible to see relevant data on the state of infrastructure, and where it exists it is mostly incomplete or not regularly updated. Also, the problem is the insufficient use of GIS systems in everyday work. Therefore, it is important to develop a functional GIS platform that would be compatible with other systems used to maintain the infrastructure and on which it would be possible to monitor the state of the infrastructure. In addition to the graphical presentation of the water utility system on the platform, it would also enable easier planning of preventive and corrective maintenance, detection of critical points of the system concerning weather conditions and changes in the environment.

In addition to the existence of such a system, it is important to develop a system for pumping and draining water from alternative sources. Given the load that the water utility system on the Croatian coast suffers during the summer months due to a large number of tourists as well as frequent droughts and occasional turbidity of water sources during rainy periods, it is extremely important to develop a system of pumping and draining from alternative sources. The system will allow maintenance of uninterrupted use, avoidance of pollution and endangerment of the health of the population. Analyzes of possible alternative sources need to be made to determine their potential locations. Also, it is necessary to determine the number of consumers who could be connected to it and make an estimate of the cost of building infrastructure. Ultimately, it is necessary to prepare the necessary documentation and resolve possible legal issues and provide a clear plan for the implementation of the establishment of a system of water pumping and draining from alternative sources.

Regarding this matter, it is also very important to reduce the impact of rainwater and seawater on the drainage system. Many Croatian cities along the coast and on the islands have a problem with rainwater collection and drainage systems because the existing system due to unsystematic and excessive construction of urban areas is not enough to withstand the pressures that arise drastically during the summer months. Another problem is floods caused by rising sea levels that cause wastewater overflows and environmental pollution. Also, seawater, due to its salinity, hurts water-utility infrastructure. Mixed wastewater and seawater go to the treatment plant where there is a negative effect of saltwater on the bio-purifier. Therefore, it is necessary to identify critical places where problems occur. Then it is necessary to develop a plan with clear guidelines for reducing the impact of rainwater and seawater on the drainage system and, if possible, establish cooperation with local governments to ensure better maintenance of water-utility infrastructure.

To implement the previous measures, it is first and foremost necessary to improve the existing water supply and drainage system. In Croatia, efforts are being made to connect water utilities to agglomerations to facilitate management and maintenance. To make this easier, existing systems need to be expanded to meet current and future needs. As part of that, it is necessary to develop strategic projects that will plan the construction of the water supply and sewerage network, upgrade the existing central wastewater treatment plants, build new treatment plants, rehabilitate existing buildings, etc.

9. PROPOSALS FOR TERRITORIAL INTERVENTION

9.1 ITALY - Marche Region

Marche Region has some bathing sites, in which can occur conditions that involve microbiological contamination of bathing waters.

As described in the previous chapters, this variety of conditions depends on the transformation and use of densely urbanized coastal areas and on the hydrographic characteristics of the inland territory and the coastal strip.

The most important ones, capable of affecting the coastal hydrodynamic characteristics, are the works of defense against erosion and the port or industrial works: these concretely modify the possibility of reducing and disfavouring the natural outflow of water from the hinterland and the overflows of sewer systems and condition, based on the hydrological regimes, the choices, which allow to reduce, if not cancel, the microbiological impact on the site.

The various options, represented in chapter 8, show the complexity of the choices, which must consider many factors and, sometimes, reach compromises, which guarantee health protection of bathers from microbiological exposure.

However, large coastal stretches, which have drainage ditches from agricultural and urbanized areas and minor streams, even during particularly intense meteoric events, do not show microbiological contamination in bathing waters.

Most of these areas are devoid of coastal defense works and the distance from the river mouths is at least 200 m: many coastal stretches that have these characteristics manage to maintain the characteristics of low or non-existent microbiological impact.

Evaluating in detail the coastal strip of Marche Region from north to south, out of 254 bathing waters only 15% presented at least one condition of microbiological non-compliance during the bathing season and only 8% show these conditions on the occasion of meteoric events : the most significant stretches of the seaside coastal strip are those of Falconara Marittima and some belonging to the Municipalities of Fano, Mondolfo, Pesaro and Ancona.

The coastal stretches adjacent to the mouths of the Musone and Chienti rivers are significantly compromised from a microbiological point of view and their mouths affect the quality of bathing water.

These areas must, however, be remediated with large-scale interventions, creating purification plants and sewage networks, which collect the urban waste produced by some agglomerations not equipped with such infrastructures. Therefore, the infrastructural action is complex, since the works to be carried out are important and expensive: however, these activities are underway and will be completed within four or five years, resulting in a benefit also for the neighboring bathing waters.

At the mouths of the Foglia, Cesano, Esino and Potenza rivers, as well as at those of the Arzilla and Tesino streams, urban wastewater collection and treatment infrastructures have been built to serve the urbanized areas, but, on the occasion of meteoric events, the sewer networks, which also collect rainwater, favor the overflows of the sewage networks themselves and of the by-passes entering the purification plants.

In these cases, the interventions to be carried out, in combination with each other, are the construction of first rain tanks and the splitting of the sewer networks from the rainwater collection networks, in order to significantly reduce the hydraulic loads in the networks and, consequently, the floods of the same.

If the hydraulic loads are high and the microbial load of the wastewater is not particularly high, in presence of factors limiting mixing of marine waters, such as coastal defense works, together with the first rain tanks, pipes can be put in place to remove wastewater beyond the cliffs themselves, in areas with low microbiological impact.

In special cases, such as that determined by the orography of the site, such as, for example, in the Municipality of Falconara Marittima, it may be necessary to adopt the most expensive solution, which is represented by the splitting of the network; this solution determines the complete conveyance of urban wastewater to the purification plant, which would not be influenced by meteoric events, while the rainwater networks, with limited microbiological load, can be discharged directly into marine waters, collecting only the initial fraction of washout of the areas that is conveyed to purification.

Chapter 8 describes in detail the interventions represented in this paragraph.

9.2 ITALY - Abruzzo Region

The regional territory records areas of intervention similar to that of the port of Pescara, according to different aspects, on which to replicate and specify the methodology defined by the Watercare project.

The following are significant cases for the re-proposal of what has been achieved within the Pescara site, specifying the main characteristics and specifications:

• Mouth of the Feltrino river

The Feltrino is a river in southern Abruzzo. It rises on the hills near the Municipality of Castel Frentano and flows into the Municipality of San Vito. It has a very low flow rate, is about 16 km long and has a total basin of about 56 km², receiving the tribute of some small streams.

The Feltrino has the primacy of the most polluted river in Abruzzo. Both bacterial and chemical pollution are high: the concentrations of Escherichia coli and mercury are high. The cause of this must certainly be sought in the high number of users (civil and industrial) that pour their discharges into this river and in the inadequacy of the purifiers present (only one and undersized).

The mouth of the river is limited exclusively to the south by the presence of a pier, while in the northern section there are longitudinal barriers to protect the coast. The latter do not allow the flow of polluted water from the mouth to move away, on the contrary they contribute to the spread of the pollutant along the stretch intended for bathing. The Coast Defense Plan (2021) provides for the removal of the river waters through the construction of a new pier to the north. This would lead to an improvement in the conditions in which the site is located as it is foreseen the protection of the mouth from silting up and therefore from the stagnation of water, along the final stretch, and the removal of polluted waters that would flow beyond the transverse barriers present.

In order to improve the quality of the water along the stretch in question, it is planned to build a first rain tank near the mouth for the collection of rainwater to the purifier and a disinfection system. An automatic sampler will be placed downstream of this system to control the quality of the water.

• Mouth of the Tordino river and mouth of the Moro river.

The Tordino river rises between the Monti della Laga in the territory of the municipality of Cortino and flows into the municipality of Gulianova. Its basin includes a total area of about 450 km², and with its 59 km of length it is the fourth river of Abruzzo.

The small river Moro flows into the town of Ortona.

Both are considered rivers of high complexity in terms of pressures and therefore record very poor water quality values in front of the mouth. An analytical activity is necessary, through the positioning of an automatic sampler near the mouth in addition to other activities of monitoring and recognition of the values of the parameters to be monitored and a census of the discharges present along the riverbed. These activities would allow a correct management and regularization of the present pressures and consequently an improvement in the quality of bathing water in the stretches adjacent to the mouth.

• Mouth of the Saline River and mouth of the Alento River

The Saline river originates in the locality Congiunti on the border between Città Sant'Angelo and Cappelle sul Tavo, flows for about 10 kilometers in an intensely urbanized and industrialized valley subject to periodic and dangerous floods and flows into Saline, on the border between Marina di Città Sant'Angelo and Montesilvano. It has an average flow rate of approximately 5.05 m3 / s and a total surface area of approximately 34 km².

The Alento river originates in Serramonacesca in the heart of the Majella national park, is about 45 kilometers long and flows into the municipality of Francavilla al Mare. The tourist port of Francavilla al Mare has been under construction for some years right next to the Alento estuary.

Both rivers considered are SIR, Sites of Regional Interest. The upstream presence of areas particularly compromised by industrial settlement systems or with the presence of high risk factors determine the need for the positioning of an automatic sampler that overcomes the issue of typical parameters measured for bathing (fecal coliforms and Escherichia coli). The use of sampling and analysis tools is envisaged to detect the presence of other types of pollutants such as heavy metals.

Following a risk analysis, linked to the de-pollution activities already planned for the SIR, the point where to place the Automatic Sampler is identified for the final stretch of the river. This would make it possible to identify the danger centers and monitor the effects of the depollution of these points on the quality of bathing water.

9.3 CROATIA

The purpose of water protection is to preserve human health and the environment, which means achieving and maintaining good water status and preventing water pollution. Among other things, it includes the improvement of ecological functions of waters and coastal waters where water quality is at low levels and achieving the prescribed water quality for certain purposes where it does not meet criteria, but also participation in planning and gradual implementation of comprehensive protection measures and systematic monitoring of measure in a basin and coastal waters as well. Also, protection includes reducing the number of hazardous substances at the source of pollution by implementing water protection measures and controlling the operation of constructed facilities and devices for wastewater treatment. That is why the development of public sewerage systems is a priority activity. The construction of public sewerage systems in tourist areas is a special problem, the solution of which should be adapted to the seasonal character of tourism. As stated in the previous chapter, there are urban areas in the coastal area and islands in Croatia where the communal infrastructure is extremely congested during the summer months due to a large number of tourists, but also during long and heavy rainy periods. Due to their specific locations near the sea and exposure to marine impact, these areas require not only infrastructural but also territorial interventions.

Areas such as the Neretva Valley, Kaštela Bay, or Vela Luka Bay are subject to the strong influence of events that occur as a result of climate change. Therefore, it is important to pay special attention to possible ways to prevent floods that occur as a result of rising sea levels or as a result of extremely high sea waves, and cause mixing of wastewater with the sea and consequently lead to coastal zone pollution. Although infrastructural interventions such as the reconstruction of the drainage system or the construction of breakwaters and protective walls are being carried out, territorial interventions such as embankment and replenishment of beaches are also needed to reduce the harmful effects of the sea in the most natural way. In this sense, it is necessary to reduce land consumption while preserving the cultural landscape and the view of the coast and historic cores. In addition to the above, it is also necessary to revitalize streams and work on their maintenance to increase the natural capacity of rainwater catchment and to reduce the possibility of the overflow of wastewater.

Considering the obligation to harmonize regulations with those of the European Union, in Croatia, according to the Water Management Strategy (OG 91/08), the construction of II. degree of wastewater treatment, except in coastal areas of lower sensitivity where, for smaller agglomerations, stage I is envisaged. This increases the connection to the public sewerage system to about 60% of the total population (or 2,660,000 inhabitants). The remaining requirements of the Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment are planned to be implemented in the investment cycle after 2023.

10. FINANCIAL FRAMEWORK

The activities carried out as part of the WATERCARE project together with the know-how accumulated over time by the partners in carrying out their skills in their respective fields, allow for an estimate of the costs necessary for the implementation of a WQIS type system. This system has the purpose of reducing the pollution phenomena of bathing water through spills from the sewer pipes during intense meteoric events and of putting into operation an alert and predictive system for the diffusion of any pollutants starting from the performance of a water quality monitoring campaign and the study of a specific mathematical simulation model.

The executive costs associated with the reduction phase of the pollution phenomena of bathing water through the spills of diluted wastewater from the sewer pipes during intense meteoric events, are strongly associated with the technical solutions identified in the decision-making process and in the preparation of feasibility studies. As previously illustrated in Chapter 8, there is no single solution for any pollution problem but the surrounding conditions have a decisive influence on what the best approach is.

Given the above, the following table aims to associate executive costs to each of the interventions described above, associated with some hypotheses better described in the description field:

Table 10 - 1 Type of intervention with economic framework.

TYPE OF INTERVENTION	**DESCRIPTION**	**ECONOMIC FRAMEWORK**	**NOTES**
CONSTRUCTION OF A STORAGE TANK	Underground tank with a capacity of 1600 m^3 and interconnection piping system	2.000.000,00 €	Plant equipped with mechanical emptying and relaunching equipment and remote control system
SUBMARINE COLLECTORS FOR THE REMOVAL OF WASTEWATER FROM	Lifting system with large capacity mechanical parts built adjacent to the	1.800.000,00 €	The economic framework does not include the construction costs for any canalizations, highly

THE COAST	CSO and submarine pipeline approximately 400 m long		variable from 300 to 1000 € / m depending on conditions
SEPARATION OF SEWER NETWORKS	The intervention consists in the construction of at least 1 new collector and any lamination and / or first rain artifacts	-	It is obviously not possible to provide an economic framework as each project is "unique" and the construction costs depend on the size of the project itself. As a reference, the costs for pipelines are reported: from 200 to 500 € / m depending on conditions

10.1 WQIS costs

The costs associated with the commissioning of an alert and predictive system for the spread of any pollutants starting from the performance of a water quality monitoring campaign and the study of a specific mathematical simulation model (WQIS), unlike the above, once the types of equipment required are known, they are better identifiable and referable to the following data.

The physical system relating to carrying out the monitoring campaign is to be seen as a prefabricated box equipped with a special connection to the electrical network, inside which the instrumentation dedicated to automatic sampling is housed. The pipelines for sampling water samples from the river and the connecting cables with external instrumentation (meteorological sensors and level measurement of the river shaft sensors) converge at the box.

The conceptual model of the management of the acquired data is composed of different levels (Figure 10.1 - 1) The datalogger firmware is responsible for interfacing with the sensors and it manages the real-time reading of the signals (analog and/or digital) output from the sensors. Data is processed and stored locally. Every 30 minutes data is then reprocessed to be collected in a single record and inserted into a pre-configured datalogger table. The Campbell Scientific's LoggerNet software retrieves in real-time raw data from remote dataloggers and inserts it into the WQIS Centralized Database (CDB).

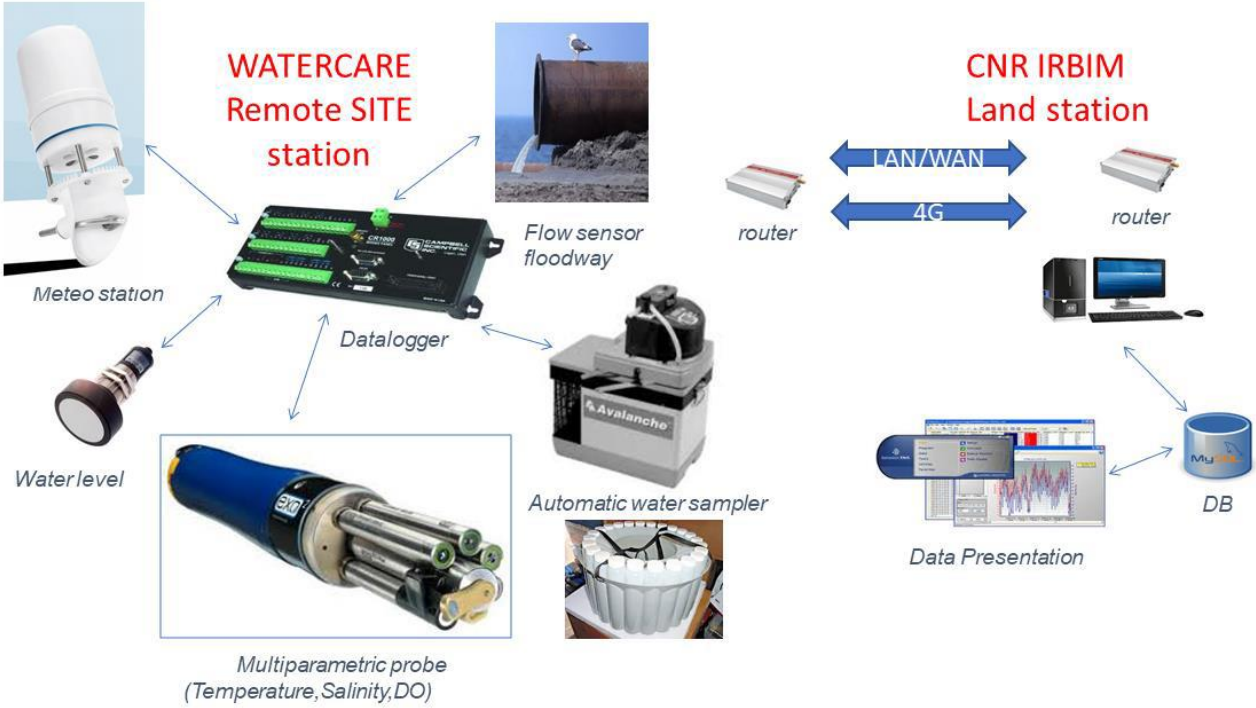


Figure 10.1 - 1 Block diagram of a WQIS stations

The WQIS real-time acquisition system includes the following equipment:

- **Campbell Scientific CR1000X** datalogger that manages the interface with sensors/actuators, data collection and remote communications;
- **Campbell Scientific ClimaVUE50** compact weather station. It measures in real-time the following parameters: wind (speed, gust, direction), air temperature, relative humidity, atmospheric pressure, solar radiation, rain gauges, lightning;
- **YSI EXO2 (or EXO3)** multiparametric probe. The sonde allows real-time river water monitoring measuring the following parameters: level, temperature, salinity, conductivity, Optical Dissolved Oxygen (concentration and saturation), turbidity, pH, redox;

-	**Teledyne ISCO Avalanche** automatic and refrigerated water sampler which takes samples (14 bottles, 900ml) for laboratory analysis of microbiological parameters of river water;

-	**Siemens Probe LU240** ultrasonic level sensor (Fano only).

Nitrate, ammonia (pH, redox Fano only) are measured with a portable multiparametric sonde in water samples collected with ISCO Automatic sampler.

Table 10.1 - 1 summarizes the parameter measured for each Watercare site station and the hardware device used

HARDWARE SENSORS	PARAMETER	FANO Arzilla Upstream	FANO Arzilla Outfall	POLA Rasa River	DUBVRONICK Neretva River	SPLIT Cetina Main	SPLIT Cetina Outfall	PESCARA Pescara River
Weather Station (ClimaVUE™50)	Wind (speed, direction, gust)	-	X	X	X	X	-	X
	Air Temperature	-	X	X	X	X	-	X
	Relative Humidity	-	X	X	X	X	-	X
	Atmospheric Pressure	-	X	X	X	X	-	X
	Solar Radiation	-	X	X	X	X	-	X
	Rain Gauges	-	X	X	X	X	-	X
	Lightning	-	X	X	X	X	-	X
Multiparameter Sonde (YSI EXO2/EXO3)	Water Temperature	X	X	X	X	X	-	X
	Salinity	X	X	X	X	X	-	X
	Conductivity	X	X	X	X	X	-	X
	Optical Dissolved Oxygen (concentration and saturation)	X	X	X	X	X	-	X
	Turbidity	X	X	X	X	X	-	X
	pH	-	-	X	X	X	-	X
	Redox	-	-	X	X	X	-	X
Level Sensor (Siemens SITRANS LU240)	River Level	X	-	-	-	-	-	-
	River Flow Sensor	**Estimated by model**	-	-	-	-	-	-

Table 10.1 - 2 Hardware devices, measured parameters and WQIS stations.

HARDWARE SENSORS	PARAMETER	FANO Arzilla Upstream	FANO Arzilla Outfall	POLA Rasa River	DUBVRONICK Neretva River	SPLIT Cetina Main	SPLIT Cetina Outfall	PESCARA Pescara River
Datalogger Cambpell Scientific CR1000X		X	X	X	X	X	X	X
ISCO Avalanche Sampler		X	X	X	X	X	X	X
Power Source		230V	230V	230V	12V Battery Photovoltaic panel	230V	12V Battery Photovoltaic panel	230V

More details about the hardware devices used can be found at the Deliverable D.3.3.1 – WATERCARE WQIS implementation, Annex 1.

Table 10.1 - 3 WQIS Watercare - Equipment/Services List.

* all prices are VAT excluded and refer to the 2019 price lists

	**Refrigerated portable automatic sampler**, Configuration 14 bottles of 950 ml in PP (1 + 1 additional), Suction line in transparent vinyl, length 150m, Strainer, Weighted Filters (x EXO probe), 3m Sampler-Datalogger connection cable	**10.000,00 €**
	**Multiparametric probe YSI model EXO 2** with 7 universal ports for sensors, including 1 port for wiper, integrated data logger for data storage, bluetooth, internal battery power supply, software for configuration, management and calibration included Level sensor inserted in the probe body: range = 0-10 m • Automatic central wiper for sensor cleaning • Temperature and conductivity sensor (Salinity) • pH and redox potential sensor • Optical Dissolved oxygen sensor • Optical Turbidity sensor Multi output DCP adapter for SDI-12 / RS232 signal acquisition Connector for standard EXO cable-probe interface to external acquirer Probe cable - length 4 m Flow Cell	**20.000,00 €**
	Multiparameter probe spare parts and accessories, calibration kit, sensor upgrade (annual maintenance costs)	**2.400,00 €**

	**Industrial Peristaltic pump** Verderflex D07 complete with flow cell and fixing frame	**2.500,00 €**
	Pump spare parts and accessories: o-ring, pipe flanges, pipe, oil (annual maintenance costs)	**300,00 €**
	Insulated BOX with door and electrical system for powering the datalogger and all electrical control and communication equipment; Power source connection; excavations / box laying / electrification 15 meters; Installation • sampler and pump collection lines, PVC pipes complete with metal protection; • central weather pole with aerial platform and weather line / sensor fixing; • Weather box-central cable laying; • Lay line and level sensor Marine samples support refrigerator specialized technical costs for installation included	**8.400,00 €**
  	• Campbell Scientific datalogger CR1000X • Campbell Scientific LR4 relay module • Compact weather station model GILL / CLIMA VUE CS • Pro YOUNG rain gauge • Siemens SITRANS Lu240 ultrasonic level sensor, 100m cable • 4G Dual Sim industrial router 4 Ethernet WAN ports, WiFi • Directional antenna for 4G industrial router • SIM M2M • Interface system with operator, equipped with	**8.000,00 €**

	touch display	
	Total WQIS station	**51.600 €**

The table lacks the hours / man for the technology transfer and the amounts related to the collection and analysis of samples, which are taken and analysed by the institutional bodies.

10.2 Figures index

10.3 Tables index

11. PUBLICATIONS AND REFERENCES

During the WATERCARE project, numerous documents were produced, already requested in the Application Form, which are listed in the following paragraphs.

For each of these documents, in addition to the references regarding the authors, a small summary of their content was also included.

11.1 Publications

1. Šikoronja M., ***Vodnogospodarska rješenja za smanjenje mikrobiološkog utjecaja na okoliš u priobalnim područjima (WATERCARE) - Water Management Solutions for Reducing Microbial Environment Impact on Coastal Areas (WATERCARE),*** *2019. HRVATSKE VODE 108, ISSN 1330-1144 (printed)/ ISSN 1849-0506 (on line)* - Published in June 2019

https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=325585&lang=en

The sensitivity of the natural resources of the Adriatic area to climate change, especially in Italy, but also in Croatia, is very high. Events of intense rain cause flooding of watercourses with various consequences for the environment, which considerably affect the quality of coastal waters and the possibility of recreational use of these bathing waters. For this reason, as part of the EU Interreg Italy-Croatia program (2014-2020), the project "Water management solutions to reduce the microbiological impact on the environment in coastal areas - WATERCARE" was launched in January 2019. coastal zones") and should last until 30 June 2021. The total budget of the project is 2,833,019.40 euros.

Several organizations participate in the project.

The main partner is the Implementation Unit of the National Research Council called the Institute for Biological Resources and Marine Biotechnology (NRC-IRBIM), and the Materials Research Center of the Istrian METRIS County of Pula and Croatian Waters as an entity legal for water management. Among the educational institutions, the Department of Molecular Biology (DISB), the University of Urbino Carlo Bo and the Department of Marine Studies of the University of Split were selected. The cooperation of these partners will provide scientific and technical support to the regional self-government units participating in the project. This is the Implementation Unit Department of Water, Soil and Coastal Protection of the Marche Region, Maritime Works and Maritime Water Services - Department of Infrastructures, Transport, Mobility, Networks and Logistics of the Abruzzo Region and of Region of Ragusa-Narento and Split-Dalmatia. In return, regional self-government units will ensure the adoption and implementation of relevant policies. A great contribution to the project will be provided by the company ASET Spa, d.d. (Municipality of Fano - Marche Region) with its practical experience in water management and wastewater treatment services.

The objective of the WATERCARE project is to bring together Italian and Croatian organizations in order to reduce the problem of possible sea water pollution through the coordinated action of a wide range of partners and activities.

The main beneficiaries of the project will be the public authorities, the regional self-government units of the coastal area and the various stakeholders (utilities, tourism bodies, citizens, bathers and tourists). By developing an innovative control and warning system, users will have support in the management of transitional and coastal waters of urban areas in order to avoid and reduce the level of bacteriological pollution of beaches that can occur after heavy rains.

2. V. Špada, ***EU fondovi u Hrvatskoj O projektu WATERCARE (INTERREG HR-IT) - EU projekt: Water Management Solutions for Reducing Microbial Environment Impact on Coastal Areas – WATERCARE,*** *2020, OSVRTI, Kem. Ind. 69 (9-10) (2020) 575–582* - Published in 2020

http://silverstripe.fkit.hr/kui/assets/Uploads/Osvrti-580-582.pdf

Sea bathing quality is an important public health concern, especially in coastal tourist areas which are heavily influenced by human activities such as urbanization, industrial development, agriculture, fishing, municipal wastewater discharge and various recreational activities. The most important indicators of marine faecal sewage pollution are microbiological indicators, and the presence of faecal bacteria indicates a potential risk of infectious diseases. The microbiological pollution at a given test point can vary significantly over time, depending on the wastewater discharge method and the meteorological and hydrographic conditions.

Criteria for assessing the quality of the sea on beaches, as well as test methods are prescribed by the Regulation on the quality of bathing sea (NN73 / 08), which is in line with Directive 2006/7 / EC of the European Parliament and of the Council of 2006 bathing, the United Nations Mediterranean Mediterranean Action Plan (UNEP / MAP) and the World Health Organization (WHO) guidelines for bathing sea quality in the Mediterranean.

The regulation prescribes sea quality standards for bathing on the beach, limit values of microbiological indicators and other characteristics of the sea. Sea quality tests on beaches are conducted at 14-day intervals, according to the Bathing Sea Quality Monitoring Program in the Republic of Croatia conducted by seven coastal counties, under the coordination of the Ministry of Environmental Protection and Energy.

3. Ferrarin C., Penna P., Penna A., Spada V., Ricci F., Bilić J., Krzelj M., Ordulj M., Šikoronja M., Đuračić I., Iagnemma L., Bućan M., Baldrighi E., Grilli F., Moro F., Casabianca S., Bolognini L., Marini M., ***Modelling the quality of bathing waters in the Adriatic Sea,*** *2021b. Water 13, 1525.* Published on May 28th, 2021

https://www.mdpi.com/2073-4441/13/11/1525

The aim of this study is to develop a relocatable modelling system able to describe the microbial contamination that affects the quality of coastal bathing waters. Pollution events are mainly triggered by urban sewer outflows during massive rainy events, with relevant negative consequences on the marine environment and tourism and related activities of coastal towns. A finite element hydrodynamic model was applied to five study areas in the Adriatic Sea, which differ for urban, oceanographic and morphological conditions. With the help of transport-diffusion and microbial decay modules, the distribution of Escherichia coli was investigated during significant events. The numerical investigation was supported by detailed in situ observational datasets. The model results were evaluated against water level, sea temperature, salinity and E. coli concentrations acquired in situ, demonstrating the capacity of the modelling suite in simulating the circulation in the coastal areas of the Adriatic Sea, as well as several main transport and diffusion dynamics, such as riverine and polluted waters dispersion. Moreover, the results of the simulations were used to perform a comparative analysis among the different study sites, demonstrating that dilution and mixing, mostly induced by the tidal action, had a stronger effect on bacteria reduction with respect to microbial decay. Stratification and estuarine dynamics also play an important role in governing microbial concentration. The modelling suite can be used as a beach management tool for improving protection of public health, as required by the EU Bathing Water Directive.

4. Penna P., Baldrighi E., Betti M., Bolognini L., Campanelli A., Capellacci S., Casabianca S., Ferrarin C., Giuliani G., Grilli F., Intoccia M., Manini E., Moro F., Penna A., Ricci F., Marini M., ***Water quality integrated system: A strategic approach to improve bathing water management,*** *2021. Journal of environmental management.* Published on June 24th, 2021

https://www.sciencedirect.com/science/article/pii/S0301479721011610?via%3Dihub

In the Adriatic Sea, massive rainfall events are causing flooding of rivers and streams, with severe consequences on the environment. The consequent bacterial contamination of bathing water poses public health risks besides damaging tourism and the economy. This study was conducted in the framework of WATERCARE, an EU Interreg Italy-Croatia Project, which aims at reducing the impact of microbial contamination on Adriatic bathing water due to heavy rainfall events drained in the local sewage network, enhancing the quality of local waters and providing support for the decision-making processes regarding the management of bathing water in line with EU regulations. The study involved the development of an innovative water quality integrated system that helps meet these objectives. It consists of four components: a real time hydro-meteorological monitoring system; an autosampler to collect freshwater samples during and after significant rainfall events; a forecast system to simulate the dispersion of pollutants in seawater; and a real-time alert system that can predict the potential ecological risk from the microbial contamination of seawater. The system was developed and tested at a pilot site (Fano, Italy). These preliminary results will be used to develop guidelines for urban wastewater and coastal system quality assessments to contribute to develop policy actions and final governance decisions.

5. Romei M., Lucertini M., Esposto Renzoni E., ***The new basin at the mouth of the Arzilla stream,*** *2021. Servizi a rete (Tecnedit edizioni), Nr. 5 – volume presented at Ecomondo -* Published in September – October 2021

https://www.tecneditedizioni.it/riviste-servizi-a-rete/

The problem of mitigating or eliminating the effects generated by the spillage of overflows of sewage networks in surface waters during heavy rains is a very common issue in built-up areas with mixed sewer networks.

This realization carried out by ASET S.p.A. - manager of the Integrated Water Service in the municipalities of Fano, Mondolfo and Monte Porzio (PU) - consists in the construction of a large-capacity tank equipped with a pumping system designed to relaunch the wastewater in an existing sewer network, avoiding spillage into the environment of the flows derived from the drainage structures of the network. The area under study is the portion of the urban area of the Municipality of Fano located at the mouth of the "Arzilla" stream, on the left side of the watercourse. The basin concerned, which extends over just over 7 hectares, is highly urbanized and characterized by an important population density with a significant incidence of the floating population.

6. A. Penna, E. Baldrighi, M. Betti, J. Bilić, L. Bolognini, M. Bućan, A. Campanelli, S. Capellacci, S. Casabianca, C. Ferrarin, F. Grilli, L. Iagnemma, I. Kristovic, M. Krzelj, E. Manini, N. Marinchel, M. Marini, F. Moro, M. Ordulj, P. Penna, F. Ricci, M. Šikoronja, V. Spada. ***A Strategic Approach to Improve Adriatic Bathing Waters: the Water Quality Integrated System.*** 2021, International Conference on River Basin Management and Protection, ICRBMP Dubrovnik, October 4th - 5th, 2021

In the Adriatic Sea, massive rainfall events are causing flooding of rivers and streams, with severe consequences on the environment. The consequent bacterial contamination of bathing water poses public health risks besides damaging tourism and economy. This study was conducted in the framework of WATERCARE, an EU Interreg Italy-Croatia Project, which aims at reducing the impact of microbial contamination on Adriatic bathing water due to heavy rainfall events drained in the local sewage network, enhancing the quality of local waters and providing support for the decision-making processes regarding the management of bathing water in line with EU regulations. The study involved the development of an innovative water quality integrated system that helps meeting these objectives. It consists of four components: a real-time hydro-meteorological monitoring system; an auto-sampler to collect freshwater samples during and after significant rainfall events; a forecast system to simulate the dispersion of pollutants in seawater; and a real-time alert system that can predict the potential ecological risk from the microbial contamination of seawater. A finite element hydrodynamic model was applied to the studied areas, which differ in hydrological, urban and morphological characteristics. Modules for transport-diffusion and microbial decay were used in order to study the distribution of Escherichia coli during significant raining events. The model results were validated against data acquired on field (water level, temperature, salinity and microbial concentrations) demonstrating the ability of the modeling suite to simulate the circulation in the coastal areas of the Adriatic Sea. Furthermore, the model simulates the main dynamics of transport and diffusion, such as fluvial and polluted waters dispersion. The modeling suite and all results obtained will serve to develop guidelines for urban wastewater and coastal system quality assessments to contribute developing policy actions and final governance decisions as required by the EU Bathing Water Directive.

7. Krzelj M., ***Water Management Solutions for Reducing Microbial Environment Impact on Coastal Areas***, *2021. Presentation at the Sealogy Conference - The European Blue Economy exhibition, FerraraFiere Congressi* – Presented on November 20th, 2021

https://www.sealogy.it/

8. Romei M., Lucertini M., Esposto Renzoni E., Baldrighi E., Grilli F., Manini E., Marini M., Iagnemma L., ***A detention reservoir reduced combined sewer overflows and bathing water contamination due to intense rainfall***, 2021*. Water 2021, 13, 3425.* Published on December 3rd, 2021

https://www.mdpi.com/2073-4441/13/23/3425

Combined sewer overflows (CSOs) close to water bodies are a cause of grave environmental concern. In the past few decades, major storm events have become increasingly common in some regions and the meteorological scenarios predict a further increase in their frequency. Consequently, CSO control and treatment according to best practices, the adoption of innovative treatment solutions and careful sewer system management are urgently needed. A growing number of publications has been addressing the quality, quantity and types of available water management and treatment options. In this study, we describe the construction of an innovative detention reservoir along the Arzilla River (Fano, Italy) whose function is to store diluted CSO wastewater exceeding the capacity of a combined drain system. River water sampling and testing for microbial contamination downstream of the tank after a strong rain event found a considerable reduction of faecal coliform concentrations, which would have compounded the impact of stormwater on the bathing site. These preliminary results suggest that the detention tank exerted beneficial environmental effects on bathing water by lowering the microbial load.

9. P. Penna, F. Moro. ***Water Quality Integrated System (WQIS) User Manual.*** Published on December 11st, 2021

https://www.researchgate.net/publication/357016059_Water_Quality_Integrated_System_WQIS_User_Manual

This manual was drawn up during the activities foreseen in the EU INTERREG Watercare project. After the design and implementation of the WQIS in the pilot site of Fano, the authors have drafted this manual in order to be used for field operation by all partners of the project.
For more information about the WQIS, you can refer to the deliverables of the project that you can find at this link:
https://www.italy-croatia.eu/web/watercare/docs-and-tools
https://zenodo.org/record/5774333#.YehQXP7MLSE

10. A. Rakić (testo), M. Bućan (fotografie), ***Utjecaj oborina sliva Cetine na kakvoću mora za kupanje - Influence of precipitation of the Cetina basin on the quality of the bathing sea***, 2021, Hrvastka Vodoprivreda, NUMBER 237 year XXIX - Published in November/Dicember 2021

https://www.voda.hr/sites/default/files/casopis/hr_vodoprivreda-237-kb_e-book.pdf

By monitoring microbiological indicators of Cetina and coastal waters, through the project "Water management solutions for reducing microbial environment impact in coastal areas" (Watercare), the risks are assessed and solutions are found to protect environment and human health.

11. Đuračić I., Tomašević Rakić D., Kristović I., Grilec D. ***PROJEKT WATERCARE – ISPITIVANJE KAKVOĆE VODE NA PODRUČJU UŠĆA RIJEKE NERETVE TIJEKOM SEZONE KUPANJA 2021. GODINE - Progetto WATERCARE – Water quality tests in the Neretva River area during the 2021 bathing season.*** Komunal, Dubrovnik, Published on December 31st, 2021

https://www.komunal.hr/vijesti/12106/#more-12106

As a partner of the WATERCARE project, Dubrovnik-Neretva County carried out project activities in the target area of the Neretva estuary.
In this area, an automatic measuring station was set up which, in addition to measuring basic climatological data under extreme hydrological conditions, also performed automatic sampling of the waters of the Neretva River. The physico-chemical indicators of water quality (salinity,

water temperature, redox potential, pH, electrical conductivity, turbidity, dissolved oxygen, oxygen saturation) are automatically analyzed by the measuring probes installed in the station, while the bacteriological load and organic (BOD 5, COD Mn, ammonium, total nitrogen, total phosphorus, E. coli and intestinal enterococci) sampled and analyzed in the laboratory. Due to the increased amount of precipitation in a short period of time (1 mm / m 2) the automatic measuring station started sampling 14 water samples at regular intervals and the notification of the start of sampling came via e- mail. Sampling and analysis of all samples were performed by the Dubrovnik-Neretva County Public Health Institute.

12. E. Manini, E. Baldrighi, F. Ricci, F. Grilli, D. Giovannelli, M. Intoccia, S. Casabianca, S. Capellacci, N. Marinchel, P. Penna, F. Moro, A. Campanelli, A. Cordone, M. Correggia, D. Bastoni, L. Bolognini, M. Marini, A. Penna, ***Assessment of spatio-temporal variability of faecal pollution along coastal waters during and after rainfall events,*** 2022. *Water 2022, 14(3), 502.* Published on February 8th, 2022

https://www.mdpi.com/2073-4441/14/3/502

More than 80% of the wastewaters are discharged into rivers or seas with negative impact on water quality along the coast due to the presence of potential pathogens of faecal origin. Escherichia coli and enterococci are important indicators to assess, monitor and predict microbial water quality in natural ecosystems. During rainfall events the amount of wastewater delivered to rivers and coastal systems is increased dramatically. Our study implements measures capable of monitoring the pathways of wastewater discharge to rivers and the transport of faecal bacteria to the coastal area during and following extreme rainfall events. We monitored the spatio-temporal variability of faecal microorganisms and its relationship with environmental variables with sewage outflow in an area located in western Adriatic coast (Fano, Italy). The daily monitoring during the rainy events was carried out for two summer seasons for a total of 5 sampling periods. Our results highlighted that the faecal microbial contamination was related to the rainy events with high flow of wastewater, with recovery times for the microbiological indicators varying between 24 and 72 hours and related to dynamic dispersion. The positive correlation between ammonium and faecal bacteria in the Arzilla River and the repercussions in seawater can provide a theoretical basis for controlling the ammonium in rivers and to monitoring the potential risk the bathing waters pathogen pollution.

13. Ordulj M., Josić S., Baranović M., Krzelj M. ***The effect of precipitation on the microbiological quality of bathing water in areas under anthropogenic impact***, 2022. *Water 2022, 14, 527.* Published on February 10th, 2022

https://www.mdpi.com/2073-4441/14/4/527

Intense rainfall can affect bathing water quality, especially in areas with poorly developed sewage systems or combined sewer overflows (CSOs). The aim of this study was to assess the impact of precipitation on coastal bathing water quality in the area of Split and Kaštela (Adriatic Sea), the urban areas where CSOs were applied. The study was conducted during two bathing seasons, 2020 and 2021. The sampling of coastal waters and measurement of physical/chemical parameters was performed every two weeks and after a precipitation event of more than 2 mm. The impact of precipitation on the quality of coastal bathing waters was not noted in the Split area nor in Kaštela, probably due to the low amount of precipitation. The quality of bathing waters in the Kaštela area was significantly worse than in the Split area, which is due to the condition of the sewage system in these areas and not the precipitation effect. It was also revealed that bathing water quality depends on the timing of sampling and the indicator against which it is assessed. Escherichia coli (E. coli) proved to be a better indicator for early morning sampling, while intestinal enterococci were better for late morning sampling.

11.2 Deliverables

WORK PACKAGE 3

D 3.1.1 – Software Utilities.

Generation of software utilities to ensure the information flow between the WQIS components. The following activities are planned, such as the identification of the modules of the modelling chain, the Integration of the WQIS components, the verifying of the efficacy of the information flow between the components and the identification of the variables to be monitored and the sensors to be used in the networks.

D 3.1.2 – WATERCARE WQIS.

Development of the WATERCARE WQIS to operate in the pilot (Fano) and target areas (Dubrovnik, Pescara, Split and Istria). The WQIS development will consist of (i) design and implementation of the hydro-meteorological monitoring network for the areas in sewers, riverines and rivers; (ii) collection of meteorological/hydrological and bacteriological data; (iii) implementation of the FOM in the pilot and target areas; (iv) implementation of the freely accessible database.

D 3.2.1 – Sampling Data set.

One suitable data set of microbial and environmental parameters measured in the pilot and target coastal areas will be generated and used in the WQIS for the alert system of bathing prohibition and safe recreational bathing.

In the pilot area of Fano and other target sites, at each emission points, the microbial and environmental sampling will be done along five transects at several points: at the emission of the discharge, then at 50, 100, 150, 200 and 300m from the coast within the recreational waters. The sampling will be done during the overflow period (based on the interval of 1-6 hours). The microbial sampling will be used to analyze the distribution of faecal discharge.

The results of microbiological analyses will be used to assess the quality of recreational waters and to provide information concerning the health status of urban wastewater and coastal system through an innovative WQIS to forecast or provide an alert system for the safe recreational bathing along the coasts at the target sites of this project.

D 3.3.1 – WATERCARE WQIS implementation.

Updating of WATERCARE WQIS at pilot and target areas through the implementation of the collected data set (act. 3.2).

D 3.3.2 – SENSOR DATA WEB.

Meteorological/hydrological sensors as remote station will be installed in 5 different sites: flow rate, rain gauges, pH-value, nitrates, ammonia, turbidity, electric conductivity, redox-potential, dissolved oxygen, temperature and water level will be measured.

WORK PACKAGE 4

D. 4.1.1 – Development and execution of an ad-hoc infrastructure tank.

Construction work of the pilot storage tank (ASET) capable of potted about 1.200 cubic meters equivalent to a return time equal to five years. The waters accumulated will be issued to existing sewage system and then purified with a delay time variable between 24 and 48 hours. The development and execution of an ad-hoc infrastructure tank will result in positive effects in terms of environmental, health and hygiene and with a significant improvement of water quality at the mouth of the stream Arzilla and bathing water surroundings.

D. 4.1.2 – Implementation/realization of the WQIS in the pilot site.

The realization of the WQIS in the pilot site will be based on the activity realized in act.3.1. CNR, UNIURB and METRIS will be involved in this activity.

D 4.2.1 – Efficiency of the storage tank.

Database of the first rainy water and response capacity of the storage tank compared to rainfall events of the action. UNIURB in collaboration with CNR, ASET and MARCHE will release the main results report.

D 4.3.1 – Guidelines to assess the quality of urban wastewater and coastal system. Guidelines will be available to all the WATERCARE sites to assess the quality of waters and to provide information concerning the health status of urban wastewater and coastal system through an innovative WQIS.

WORK PACKAGE 5

D 5.1.1 – Alert Tool for the Bathing Water Management.

The realization of the Alert Tool software for the bathing water management in the pilot and target sites allow to send immediate alerts in case of an emergency; automatically they will be notified via text, phone or e-mail. A real-time alert system - based on a now-casting procedure, providing forecasting parameters up to several hours ahead – will be able to preventively identify the potential ecological risk from faecal contamination of bathing waters due to high unusual local riverine floods caused by high rainfalls under climate anomalies.

D 5.2.1 – Simulations for the validation of the Alert Tool.

Three simulations will be done in the each of 5 sites in order to validate the Alert Tool and consequently to send the right communication to the competent authorities and stakeholders.

D 5.2.2 – Alert Tool final release.

After the validation throughout the envisaged simulation the final version of the Alert Tool for the Bathing Water Management will be released.

12. CONCLUSIONS

WATERCARE project wanted to highlight a particular aspect of the impacts that can be generated in the protected areas of the Water Framework Directive, such as that of the microbiological impact in bathing water.

The microbiological impacts that have particular relevance in the WFD are those that occur in the waters intended for bathing and in those for drinking water.

The project wanted to highlight the causes of these contaminations in order to be able to manage them, in order to guarantee bathers health protection from exposure to microbiological risk.

The European legislation on the quality and management of water used for bathing (Directive 2006/7 / EU) and the national legislation for its implementation, in the two countries that participated in the project, have been fully understood, although in different ways with regard to the aspect of exposure to microbiological contamination.

First of all, European legislation indicates as protected areas the waters used for bathing, indicating specific objectives, represented by the values of the microbiological parameters Escherichia Coli and Intestinal Enterococci, considered indicators with a general and specific character, also representing the contamination that can derive from the presence of microorganisms pathogens.

The control of these parameters and sampling frequencies are determined by the characteristics of the bathing water and allow its classification, based on the calculation of a percentile.

Italy, with Legislative Decree 116/2008 and subsequent Ministerial Decree 30/03/2010, has developed community legislation, by monitoring the quality of bathing waters, management measures to reduce the risk of microbiological exposure and compliance with limit values (for the two microbiological parameters Escherichia Coli and Intestinal Enterococci), after which the management measure of temporary closure (YT) of the bathing water (BW) must be adopted.

Croatia has adopted the water laws OG 153/2009 and OG 56/2013 and, for bathing waters, has adopted the specific regulation (OG 51/14), in which local public bodies are obliged to provide Croatian Waters (Legal entity for water management) the quality of bathing water and the evaluation of the monitoring for each bathing water, in their jurisdiction, every year after the end of the bathing season, in the manner provided from the directive.

River Basin Management Plan for the period from 2016 to 2021 issued by Croatian Waters prescribes measures for bathing waters management, protection and preservation. Even though the current Croatian legislation mostly relies on a collaborative approach between quantitative and qualitative data derived from measurements, sampling, testing and information obtained by the public participation, the whole management cycle could be improved and more efficient.

With regard to the above-mentioned cooperation, and within the given legislative framework, analytical indicators have been defined that indicate the pollution of bathing water. The general goal is to improve the state of bathing waters in the entire Croatian territory. Such is comprised by Regulation on the Water Quality Standard (OG 96/19) that prescribes the water quality standard for surface waters, including coastal and territorial sea waters and groundwater, special water protection objectives, criteria for determining water protection objectives, conditions for extending the deadline for achieving water protection objectives, elements for assessing water status, monitoring water status and water status reporting. The Annexes of the OG 96/19 prescribe the limit values for the determination of the ecological status of waters correspondingly bathing water. Besides this, the Regulation on Sea Bathing Water Quality (OG 73/08) prescribes the sea bathing water quality standards with microbiological indicators. Also, The Water Condition Monitoring Plan in the Republic of Croatia for 2021 conducted by Croatian Waters prescribes indicators for sampling and testing of bathing water, hydrological measurements for monitoring ecological and chemical status and indicators for testing the quantitative status of bathing water.

The specific regulations of the two Countries differ substantially in the management of analytical non-conformities detectable during monitoring, defined by a specific control calendar throughout the bathing season.

If the classification is poor for at least 5 years, the bathing water must be permanently banned (YP) until the measures to improve and mitigate the causes of contamination are implemented and a new compliance of the water is established; this condition is valid for both countries and derives directly from European legislation, for which the analytical result of the microbiological parameters, in relation to defined values within specific ranges, determines the class they belong to.

However, this procedural method, indicated by the European standard, fails to completely avoid the exposure of bathers to microbiological risk in the event of contamination and impacts caused by the introduction of (urban) wastewater into bathing waters.

For this reason, the Italian legislation provides, upon exceeding the limit values defined by the national law, the temporary closure (YT), through well-defined procedures, and also provides for clear communication to the public during the interdiction period.

In this case, the European standard also distinguishes cases of "short-term" pollution, ie when the contamination does not exceed a period of 72 hours, and the more significant ones, which, on the other hand, persist for periods longer than 72 hours.

The causes of microbiological contamination can be identified mainly from urban wastewater discharges, i.e. from those waters that, in densely populated areas, must be collected and treated in compliance with another European directive, 91/271 / EEC on urban wastewaters.

In some cases, much rarer, even the supply of water from surface ditches draining from non-urbanized areas can cause temporary contamination, but they are not, in most cases, relevant for health purposes.

The discharges that derive from the urban wastewater collection and treatment system, main cause of water contamination and impact, can be divided into two main cases: those coming from purification, which have a continuity character, and those coming from the collection, through the spills of the CSO - Combined Sewer Overflow, which are discontinuous and occasional, and mainly and significantly depend on meteoric events.

The drainage from the sewage artifacts is characterized by untreated wastewater which, on the occasion of significant meteoric events, derives from the sewage collection systems that also receive rainwater from the run-off of the urban waterproof surfaces; these types of discontinuous discharge can be determined directly by the overflows of the networks or by the overflows and by-passes placed at the head of the purification plants.

While the discharges produced by the purification plants are obtained after appropriate and adequate treatments, such as disinfection which takes place through various treatment methods, those coming directly from the CSOs from the sewer networks do not undergo any treatment; for this reason, despite the strong dilutions caused by the high quantities of rainwater that are collected in these systems, the CSOs discharge important quantities of microbiologically contaminated water into the receiving water bodies, causing, in the case of bathing water, a temporary decline in the quality of the waters.

The type of site in which these overflow waters from the sewer networks are discharged significantly affects the natural processes that maintain the microbiological and chemical characteristics of the waters themselves and their compliance.

The diffusion and mixing of waste water depend on various factors (orographic, morphobatimetric, structural such as coastal defense works, marine weather) and all these characteristics differ profoundly between western Italian and eastern Croatian Adriatic coasts.

It has been clearly verified that, with the same microbiological pollutant load spilled into the sea, the impacts that are determined are significantly different, not only for the specific site characteristics, as described in chapter 5, but also for the oceanographic conditions of the Adriatic Sea basin, where the coastal characteristics are totally different.

This means that urban wastewater or river waters, with very different degrees of salinity, are in any case easily mixed along the Croatian coasts, while in the Italian ones this happens if there are mainly coastal defense works or, in general, artificializations along the coast line.

Wind forcing from the east quadrants (quadrant I and II) also have a significant impact along the Italian coastal strip, an aspect that is not observed along the Croatian coast.

From the above it is clear that Italian coastal sites are more sensitive to the introduction of microbiological pollutants into bathing waters.

It is important to highlight this, because significant microbiological impacts are determined only on the occasion of meteoric events with abundant rainfall, such as to drain the sewer networks.

In fact, as described in the institutional websites of the two Member Countries, bathing waters have a prevalent character of excellence.

However, even for short periods, the quality can be compromised and for this reason, in addition to the continuous monitoring of bathing waters, interdiction measures and measures that provide for the construction of containment infrastructures must be implemented.

The WATERCARE project wanted to develop a system that allows to acquire and integrate the information necessary for the description of a meteoric event, the quantity and quality of urban wastewater discharged, their chemical and microbiological characterization and that of the receiving water body and the bathing waters.

Depending on the characteristics of the site, a WQIS system similar to that adopted in the five pilot sites of the project must be designed and adapted; the five pilot sites have different characteristics and react differently to the impacts described above.

The most unfavourable weather and sea conditions are those in which the mixing of freshwater, wastewater or fluvial waters stratify on the surface, because the receiving marine waters are in a calm condition.

In these conditions, which usually occur with concomitant conditions of high solar radiation, the microbial load could even increase.

In the event that the spills occur in rough sea conditions or at least with evident wave motion, the mixing of the waters is facilitated and the salinity of the marine waters favours the inhibition of microbiological development, favouring the reduction of the impact around 24/48 hours (short-term pollution).

Therefore, it is necessary to be able to describe in detail the input and mixing processes, defining the spatial and temporal areas that characterize the impact.

These assessments and descriptions are the aspects and information created and produced by the FOM model which uses both the data produced in real time by the WQIS system and those obtained from the sampling of the microbiological and chemical parameters carried out in the impacted site; the sampling strategy to be carried out must define the spatial and temporal scope of impact duration and for this the sampling must be repeated for the time necessary to describe the restoration of the usual conditions and compliance of the site.

This information, based on the continuously analyzed data, can also define predictive scenarios, which make it possible to identify and indicate the conditions that can modify and alter the compliance of the site, representing diffusion and persistence scenarios of the microbiological impact.

The representation of the events and the simulations defined for critical scenarios allow the competent bodies to adopt very limited and defined actions and measures, capable of concretely protecting the bathers.

The possibility of giving indications that advise against the use of bathing waters, and their management, in moments related to the spillage of urban wastewater from CSOs and watercourses that can bring microbiological polluting loads is one of the management aspects of water most significant bathing of the directive.

The operations to be implemented are both those concerning the management measures to be applied in real time, in order to avoid, firstly, bathers exposure to the health risk and, secondly, to combat contamination and analyze it in its all aspects, both those of an infrastructural type which have the purpose of limiting or, at best, eliminating the impacts of contamination on bathing waters.

With reference to the management measures to be applied in real time, Marche Region has proposed a mechanism for managing seawater subject to flooding, which various Municipalities have willingly adopted, put into practice and tested by various bathing seasons, to counteract the potential contaminating effects due to spills of urban wastewater from overflows, by-pass systems and mouths of rivers and streams, following intense rains, pending the adaptation of existing sewer and plant infrastructures and the construction of those that do not yet exist (see chapter 7 of these Guidelines).

A particular act was issued by the Mayor, of a particular act, called Management Union Order (MUO), which, issued before the start of the bathing season, describes the procedures for closing and reopening the BWs subject to floods of untreated urban wastewater, following intense and/or prolonged rainfall. This act is based on the precautionary principle, according to which it is necessary to protect the health of bathers and of all the people who use the marine resource on a continuous basis, even in the period of time between the start of the urban wastewater supplies or ditches and rivers waters contaminated by these floods due to intense rain events and the analytical results on samples taken by ARPAM.

The impact and evolution of a critical scenario in predictive terms can be achieved thanks to a hydrodynamic analysis of the application area, which can be represented and described by the FOM (Forecast Operation Model), that is by the hydrodynamic finite element model, as well as applied to the five study areas in the Adriatic Sea, which differ from each other in terms of urban, oceanographic and morphological conditions.

In these areas, the dispersion of E. coli concentration was simulated and predicted thanks to transport-diffusion and microbial decay modules. The model results were evaluated with respect to water level, sea temperature, salinity and E. coli concentrations acquired in situ, demonstrating the ability of the modelling suite to simulate circulation in coastal areas of the

Adriatic Sea, as well as the main dynamics of transport and diffusion, such as the dispersion of the river plume and polluted waters.

Guidelines on sampling strategy and analyzes on microbial and environmental variables will be useful for decision makers (competent authorities) to implement new reliable sampling strategies and mitigation measures, in order to avoid or reduce the closure of bathing areas for periods of time needed, as is now the case. In chapter 6, the following points were focused: i) evaluation of the presence and quantification of faecal pollution levels and its space-time variability along a coastal area affected by river discharges; ii) analysis of the potential relationships of the abundance and distribution of faecal bacterial indicators with the main environmental variables; iii) identification of the origin and time of decay / persistence of microbial contamination during extreme rain events.

Once the situations in which the five pilot sites are located, both Italian and Croatian, have been summarized, it was possible to verify how the various contaminations develop in these places: for example, with reference to the Arzilla stream, they are strongly linked to the rainy phenomena.

These aspects allow the development for the construction of infrastructures, adequately identified, which can reduce or eliminate the impact on bathing waters. A concrete example was that relating to the construction of the first rain tank in the terminal section of the Arzilla stream before entering the bathing water (IT011041013005 and IT011041013032) facing the mouth of the stream itself.

Considering, in fact, the Arzilla torrent, during the 2021 bathing season it was possible to verify that the succession of three important rainy events, at the end of August and at the end of September, despite having caused contamination of the bathing water, did not cause any flooding of the first rain tank, which collects the waste water discharged from the sewer system (the volumes have been totally contained).

This means that, if, on one hand, the infrastructure created allows the containment of urban wastewater increased by the volumes of rainwater collected in the sewer networks, it is, however, necessary to always take into account the meteoric contributions and the contributions of the discharges present, also increased by meteoric waters, of the whole hydrographic basin that watercourse mouth subtends: in fact, mouths of streams and rivers receive, and therefore throw into the sea, waters coming from their own hydrographic basin.

Therefore, the study, knowledge of events and impacts and any interventions to resolve critical issues must take into consideration the basin in all its completeness and complexity.

In fact, interventions that can be carried out along coastal strip or in the terminal stretch of streams or rivers, so-called "downstream", focused on reducing the impacts due to the discharges of urban wastewater into bathing water, through the treatment or the removal of waste water, can and must be integrated with an approach that aims to mitigate any microbiological contamination produced by "upstream" impacts, or by reducing the contamination of rainwater drainage, both through the separation of networks and with the reduction of the supply of rainwater into the network through the use of sustainable drainage solutions, that is, which avoids or reduces mixing of two types of drained water: rainwater and wastewater from urban sewage systems.

Although these are solutions that cannot be extended to the entire basin, especially in already urbanized contexts, this type of interventions have the advantage of being able to be implemented gradually in the context of planning relating to urban water management and more generally related to rainwater drainage.

Volume 2 of Deliverable D.4.3.1 is dedicated to the description of different solutions to mitigate the impact of urban wastewater discharges on coastal areas, the analysis of which should include both downstream mitigation measures, which aim to treat polluted water before it is discharged to the final recipient, and upstream mitigation measures, which focus on the sewer network.

Downstream solutions may include:

• construction of new waste water treatment plants or upgrading of existing ones to prevent discharge of untreated water;

• water treatment from combined sewer overflow and upgrading of existing structures to reduce impact on receiving bodies.

Upstream solutions aim to reduce inflow of unpolluted rainwater into wastewater networks, for example through separation of rainwater and wastewater networks or use of sustainable drainage solutions. The same document identifies possible solutions for each of the main categories listed above, providing a general description, the field of application, some indications on parameters and sizing methods and the main characteristics of each.

Concerning Croatian coast, the installation of WQIS devices and the use of the application will facilitate the monitoring of bathing water quality and will be able to obtain accurate and up-to-date data for each pilot area. This will reduce the possibility of infecting the population and the time required to react. Thus, WQIS will enable quality data collection on bathing water quality and insight into the effects of rainwater on bathing water quality. Also, in addition to natural factors, the installation of WQIS devices will enable the monitoring of human factors on bathing water pollution. This primarily refers to industrial and water and sewage infrastructure and tourist facilities located in the areas where the device is installed.

Given that most of the water and sewage infrastructure is outdated and overburdened, and during the tourist season in Croatia due to the increased number of tourists and vessels, pressures from the sea are growing, the use of WQIS devices will play an important role in monitoring bathing water quality. If there are significant deviations from the normal, reference values, WQIS will signal the pollution on time and it will be possible to alert the competent services that will be able to prevent the spread and remediate the pollution. The data collected by the WQIS device will also be of significant importance in the future development of Croatian local urban plans and pollution prevention and protection measures.

Information to the public is one of the most significant aspects of bathing legislation. In fact, both Article 12 of Community Directive 2006/7/EC, and Article 15 of Legislative Decree no. 116/08 (Italy), provide precise indications in this regard, encouraging and stimulating use of "*adequate means and communication technologies, including the Internet, to promptly promote and disseminate information on bathing waters*".

With reference to Italy, the Ministry of Health provides detailed information regarding water control, bathing bans and international activities thanks to its Bathing Water Portal, a web page that is easily accessible and can be consulted by the public, able to provide and receive real-time information on water quality.

Marche Region, in particular, has an institutional portal, in which, within the section dedicated to water protection, it proposes specific pages for bathing waters, in which, in addition to the legislation and regional acts issued, it is possible to find the administrative procedures of the past and current bathing seasons.

Also in the regional context, the Regional Agency for Environmental Protection of the Marche, in the bathing section of its institutional portal, not only provides a complete overview of data concerning past seasons, but also shows updated real time information of analytical data (compliance/non-compliance) of regional bathing waters, based on the monitoring calendar for the current bathing season. On this web page, also accessible from Marche Region website, you can find the profile and information board of each BW.

Finally, in the local area, each seaside municipality dedicates to bathing its own section of the institutional website: in these pages you can find both the documents and the closing and reopening data of the bathing waters during the current season.

With reference to Croatia, following Directive 2006/7/EC of the European Parliament and the Council on public information, and according to the Regulation on Sea Bathing Water Quality (OG 73/08) and the Regulation on Bathing Water Quality Standard (OG 96/19), the status of bathing waters in Croatia is regularly monitored. In addition to water quality, the profile of the bathing area, the existence and maintenance of sanitary facilities or sewage outlets located nearby are monitored. The beach concessionaire or local self-government body is obliged to display an information board with information on the quality of bathing water and information on possible extraordinary events on the beach to inform bathers promptly.

On the website of the Institute of Oceanography and Fisheries, it is possible to access the interactive map which shows the points of bathing water quality testing with the corresponding quality ratings assigned with colours: blue (excellent), green (good), yellow (satisfactory) and red (unsatisfactory). Based on the monitoring results, individual, annual and final bathing water quality assessments are determined. The map is available to the public and holds information on bathing water quality in all seven coastal counties and correspondingly on a local level within each county. Besides quality, additional informative parameters such as air temperature, sea temperature and salinity, wind direction and speed are available on the interactive map as well.

Based on the sampling and analysis of samples of all types of water, including bathing water, the Public Health Institute in each coastal county prepares annual reports summarizing all relevant parameters and results of bathing water quality analyses to inform the public about the condition and final assessment given after the bathing season. The Institutes of Public Health of the Istria County, Split-Dalmatia County and Dubrovnik-Neretva County in which pilot sites (Raša, Cetina and Neretva) are located set targets for improving bathing water quality during the upcoming bathing seasons. However, the results are uploaded and available on the previously mentioned website.

As part of the Watercare project, the Split-Dalmatia County has developed the WaterCare application, which seeks to improve the quality of bathing water. The application is made following the Water Framework Directive (WFD) and has an integrated GIS system for reviewing locations where analyses and presentation of bathing water quality parameters were performed. The presentation of bathing water quality results is available to the general public, while access to some specific data requires registration, which is only available to decision-makers.