D.5.2.2 – Alert Tool final release

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	36 months

Related activity:	5.2 – Validation of the Alert Tool for the Bathing Water Management
Deliverable name:	D.5.2.2 – Alert Tool final release
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	Split-Dalmatia County (PP5-SDC)

Status	Final
Author (s)	Pierluigi Penna, Christian Ferrarin, Mauro Marini (LP-CNR) Antonella Penna, Fabio Ricci (PP4-UNIURB) Martin Bucan (PP5-SDC)
Version	1
Due date of deliverable	30/09/2021
Delivery date	30/06/2021

INDEX

1. INTRODUCTION

In this report, we describe the Alert Tool System for assessing microbial pollution in coastal areas which consists of a real time monitoring system, a numerical model suite (FOM, forecasting operational model) and a set of procedures for a decision supporting system.

The adopted approach realises a seamless transition between different spatial scales, from the river mouth to the open sea, and adopts a high spatial and temporal resolution of the forcing and boundary conditions that drive the simulations. The model is evaluated against observations in the coastal areas, illustrating the capability of this tool in simulating the water circulation as well as the dispersion and decay of microbial pollutants. The model has been applied to the five pilot sites in the Adriatic Sea. The model evaluation is limited by the availability of site-specific observations (see the deliverable 5.2.1).

The Alert Tool system makes it possible to highlight critical situations, which can arise during adverse weather conditions. The FOM forecasting model 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 wastewaters, coming from the inputs of sewerage systems and courses of natural water, into which these inputs are introduced.

In practice, the WQIS 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 favours preventive management: by adopting the measures 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.

2. Forecast Operational Model

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 horizontal discretization of the state variables is carried out with the finite element method, with the subdivision of the numerical domain in triangles varying in form and size. Such a method has the advantage of representing in detail complicated bathymetry and irregular boundaries in coastal areas. Thus, it can solve the combined large-scale oceanic and small-scale coastal dynamics in the same discrete domain by using unstructured meshes.

2.1 Validation of the FOM

The applications of the SHYFEM model to the five study areas in the Adriatic Sea were validated by comparing the simulation results with various sets of observations. The different study areas are monitored by several observational networks, which differ for the observed parameters, type of monitoring instruments and frequency of acquisition. The monitored parameters used in the validation procedures are grouped into the following three categories: hydrodynamic (water levels), physicochemical (water temperature and salinity) and microbial (*E. coli* concentration). Generally, the comparison with the tide gauge data confirmed the good performance of the SHYFEM model in simulating hydrodynamics in the Adriatic Sea. Moreover, the numerical model provides a realistic representation of the *E. coli* distribution in the nearshore waters, describing the marked decrease in the bacteria concentration observed from the river mouth towards the open sea. The description of the model validation is reported in deliverable D.5.2.1. Fig. 1 reports the comparison of the model results with the observations at the Rasa River site.

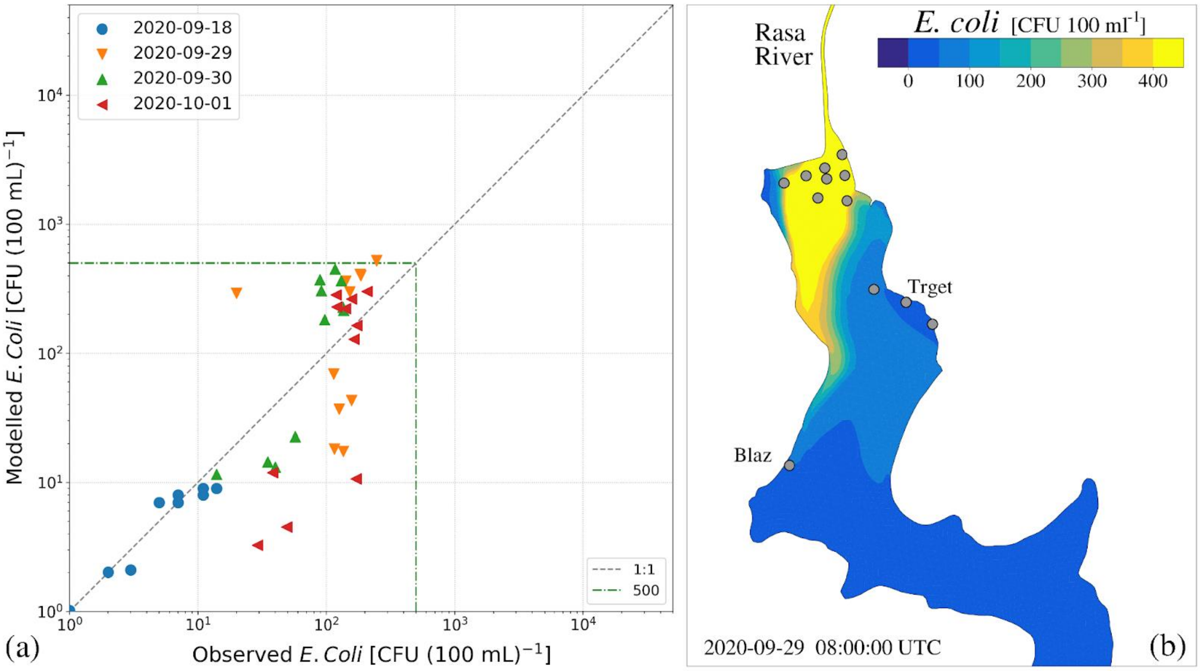

Figure 1: a) Scatter plot of simulated versus observed *E. coli* concentrations (2020 surveys). b) Simulated distribution of *E. coli* on 29 September 2020 at 08 UTC. The grey dots mark the sampling stations.

2.2 FOM operational implementation

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 project's WEB system jointly river discharge and rain forecast (Fig. 1).

The model has been implemented to run operationally every day 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 forecasts are forced by:

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

For the Arzilla River at the Fano pilot area, the freshwater discharge is provided by the drainage basin forecast system managed by the Regione Marche, thanks to a collaboration within the framework of the Interreg Italy-Croatia STREAM project.

FOM provides a two-day forecast for the five project pilot areas.

3. Alert tool final release

The flow of information stored in the Water Quality Integrated System (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. The alert tool has been tested and applied to the five pilot sites in the Adriatic Sea. These tools are the WQIS results and allow generation and delivery of FIB 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 and any hardware abnormalities detected in real time.

The figure 2 below shows the rain threshold set at 1mm/30min. If the rain that falls in the last 30 minutes exceeds 1mm, a specific alert is sent. An example of email notification is shown in Figure 3.

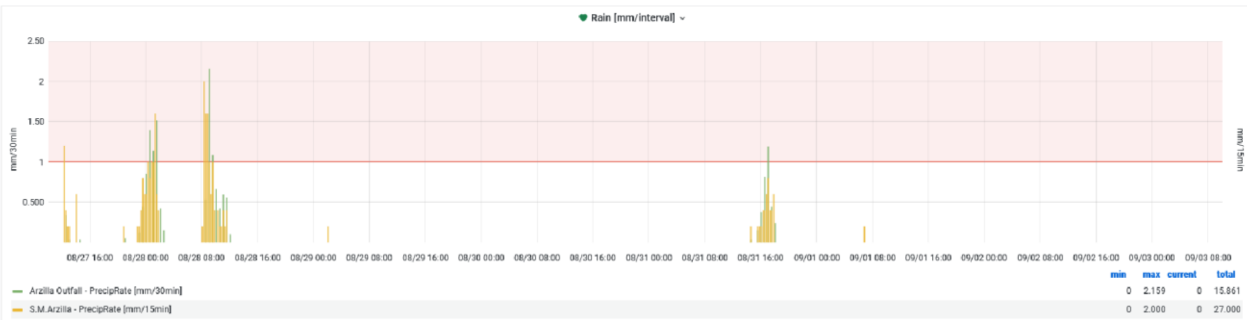

Figure 2. The graph shows the rain threshold set at 1mm/30min. If the rain that falls in the last 30 minutes exceeds 1mm, a specific alert is sent.

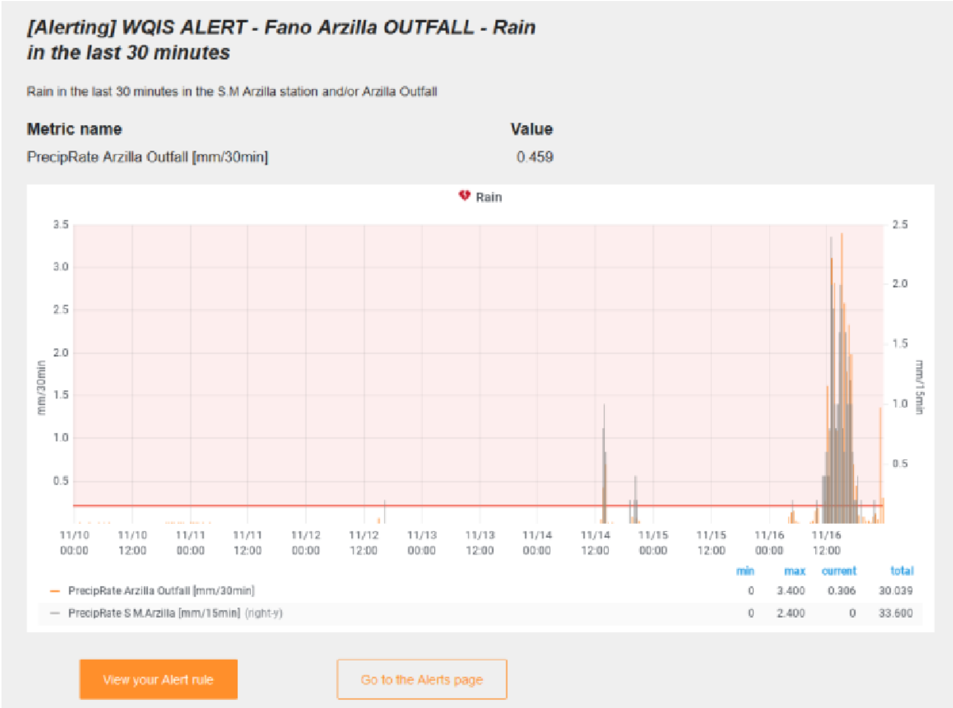

Figure 3. Example of notification by e-mail.

It is also possible to set the thresholds for other variables such as the activation of the CSO or on the level of rain or flow provided by the drainage basin forecasting system ECMWF model.

For more details about the Alert tool see D.5.1.1–Alert Tool for the Bathing Water Management

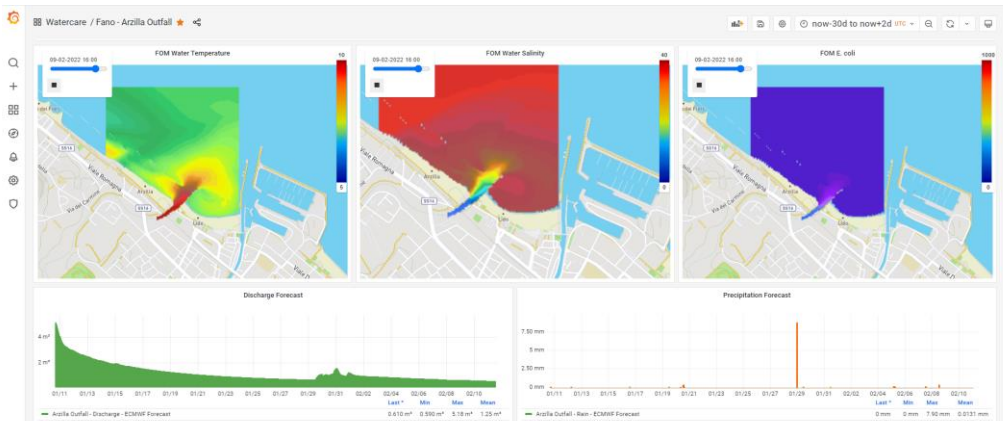

Figure 4. Visualisation of the FOM, river discharge and rain 2-day forecast at Fano pilot site.

The stakeholder, after having received a warning alert generated for example by rain and flow forecasts, will receive a further alert generated by the rain measured in real time. By accessing Grafana he will find a synoptic with useful information to make a decision on which area to close and for how long (see Fig. 4).

The Alert Tool and the FOM forecast favours bathing water management by adopting the measures 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.

Concluding, the adopted approach realises a seamless transition between different spatial scales, from the river mouth to the open sea, and adopts a high spatial and temporal resolution of the forcing and boundary conditions that drive the simulations. The model is evaluated against observations in the coastal areas, illustrating the capability of this tool in simulating the water circulation as well as the dispersion and decay of microbial pollutants. The model has been applied to the five pilot sites in the Adriatic Sea.

The Alert Tool is a new tool that can help local authorities make critical decisions with regard to coastal waters management and beach access.

In particular:

- it improves coastal area management by local authorities by providing decision-making support with regard to water management in urban areas and beach closures due to seawater bacterial contamination.
- allows beach managers to quickly inform the population and bathers.
- it boosts the tourism economy.
- it facilitates adaptation to EU WFD and Marine Strategy Framework Directive requirements.

4. WATERCARE Visualization tool

Within the framework of the 5.2 activity, Split Dalmatia County developed a visualisation tool to be used as a web application with the following functionalities:

- **Location registry** – the system integrates data from 5 different locations from Watercare project
- **Data visualisation** – the system provides visualisation options (charts, tables, text descriptions, images, …) for collected water and environment data
- **GIS module** – basic GIS functionality to represent spatial data
- **Authentication and authorization** – access restriction for specific app segments, user and role management.

The tool can be accessed online by an user by the following link:
https://watercare.com.hr/home

Figure 5: Image of the tool home page

A set of guidelines are provided, so that users can easily sign up and login, and benefit of all the above-mentioned tool functionalities.

Bibliography

Pierluigi Penna, Elisa Baldrighi, Mattia Betti, Luigi Bolognini, Alessandra Campanelli, Samuela Capellacci, Silvia Casabianca, Christian Ferrarin, Giordano Giuliani, Federica Grilli, Michele Intoccia, Elena Manini, Fabrizio Moro, Antonella Penna, Fabio Ricci, Mauro Marini. 2021. Water quality integrated system: A strategic approach to improve bathing water management. Journal of Environmental Management.,295, 113099, doi:10.1016/j.jenvman.2021.113099

Christian Ferrarin , Pierluigi Penna, Antonella Penna, Vedrana Spada, Fabio Ricci, Josipa Bilic , Maja Krzelj, Marin Ordulj, Marija Šikoronja, Ivo Đuraˇci´c, Luca Iagnemma, Martin Bu´can, Elisa Baldrighi, Federica Grilli, Fabrizio Moro, Silvia Casabianca, Luigi Bolognini and Mauro Marini. 2021. Modelling the Quality of Bathing Waters in the Adriatic Sea.. Water. 13 (11), 1525, doi:10.3390/w13111525

E. Manini, E. Baldrighi, F. Ricci, F Grilli, D. Giovannelli, M. Intoccia, S. Casabianca, S. Capellacci, N. Marinchel, P. Penna, F. Moro1, A. Campanelli, A. Cordone, M. Correggia, D. Bastoni, L. Bolognini, M. Marini, A. Penna. 2022. Assessment of spatio-temporal variability of faecal pollution along coastal waters during and after rainfall events. Water Submitted gennuary 2022

Luna G.M., Manini E., Turk V., Tinta T., d'Errico G., Baldrighi E., Baljak V., Buda D., Cabrini M., Campanelli A., Cenov A., Del Negro P., Drakulović D, Fabbro C., Glad M., Grilec D., Grilli F., Jokanović S., Jozić S., Kauzlarić V., Kraus R., Marini M., Mikuš J., Milandri S., Pećarević M., Perini L., Quero G.M., Šolić M., Lušić D.V., Zoffoli S., 2019. Status of faecal pollution in ports: A basin-wide investigation in the Adriatic Sea. Marine Pollution Bulletin 147: 219–228. doi:10.1016/j.marpolbul.2018.03.050