FPCUP Action 2019_2_46:

User uptake in the framework of bathing waters management

Management tools for bathing waters

Involved technical and scientific staff for ISPRA - Italian Institute for Environmental Protection and Research)

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Summary

1 Objectives of FPCUP Action "2019_2_46: User uptake in the framework of bathing waters management"

The FPA concluded between the European Commission and the Caroline Herschel Framework Partnership Agreement (FPCUP) consortium (275/G/GRO/COPE/17/10042) includes an Action Plan and Governance scheme describing the general scope of actions to be implemented by the consortium and the interactions among the consortium members and the European Commission.

This second Specific Grant Agreement (SGA) contained national user uptake measures and coordination activities for the Consortium selected by the Commission to implement the Action Plan for Copernicus User Uptake in the framework of FPCUP.

Coherently to the planning and scheduled deadline, the action "2019-*1-46: User uptake in the framework of bathing waters management (ISPRA)"* started in September 2021 and was concluded in November 2022.

The Objectives of the action were developed coherently to the objectives of the EU Directive on Bathing Waters (2006/07/EC). This EU Directive deals with the management of bathing waters to protect bathers' health by improving environmental conditions. In particular, the Directive is mainly focused on the concept of prevention. It stresses the importance of identifying pressures and impacts in terms of nature, spatial and temporal extension. This approach requires tools that provide all the information necessary to properly characterize pressures and impacts. Furthermore, forecasting an impacting event on bathing waters directly help with the enforcing of measures to reduce/prevent effects on bather's health, on the environment and economy.

In this framework, Copernicus products provide useful data and services that are the basis of several ongoing downstream services dealing with bathing waters management.

The Italian National Network System for Environmental Protection (SNPA), coordinated by ISPRA, published new guidelines (2021) aimed to provide criteria for analysing natural and anthropogenic pressures that may lead to degradation of bathing water quality and to better manage their area of influence. These guidelines also highlight links with Copernicus products and the critical issues in the management of bathing waters useful for the potential development of Copernicus downstream services.

The aim of this workshop is to involve final users of the coastal communities into this process, showing all the potential of Copernicus products, and to gather users' needs to propose a more homogeneous approach among the different Italian Regions.

Within the framework of the bathing waters management, a workshop was organized in Italy by ISPRA to update national and international criteria aimed at improving the modelling system capability (e.g., forecasting scenarios) and the analysis of natural and anthropogenic pressures that are a potential cause of degradation of bathing water quality. ISPRA carried out the following activities:

- Administrative work supporting the workshop organization.
- Meeting with national and regional authorities and universities aimed at drafting national guidelines regarding the management of bathing waters.
- Networking and coordinating activities with other national institutes and agencies operating in the field of bathing waters: ISS, Regional environmental protection agencies.

- Drafting of the questionnaire for identifying requirements by entities dealing with the management of bathing waters (National System for Environmental Protection community, Local Administrations, National Government, Research Institutes) to identify potential downstream services to be built upon common needs.
- Coordination with actions 2019-2-43 and 2019-2-44, to maximize the exploitation of the possible outcomes of the three actions.

National Institutes, Regional Agencies and Universities were involved in the networking and coordinating activities for updating the criteria necessary to improve the modelling system capability. Experts contributing to the redaction of the Italian Guidelines for supporting waters bathing management were also engaged.

Output and results of this action:

- Workshop in November 2023
- Questionnaire redacted to carry out a survey among the participants of the workshop for assessing the usefulness of the event and highlight specific points of view.
- Report containing an explanation of the workshop results regarding Copernicus impact for different application domains.

2. General overview of management issues for characterizing pollution sources and delimiting bathing areas

Pollutants have serious impacts on the quality of bathing waters. Therefore, it is necessary to identify the sources of pollution and the receiving coastal zones, considering that the entire drainage basin could be the possible source of pollution for the connected bathing areas.

According to the different land use included in the drainage basin, i.e. agriculture, industry, urban settlements, the pollution sources can be of different typology and intensity.

Other sources of pollution are to be added, because located in the coastal areas such as discharges of wastewater disposal networks or related to infrastructures near bathing waters like power plants or port basins.

Except for the sources near the coastal zones, bathing waters quality is closely associated to the water quality of the hydrographic network.

In compliance with the Directive 76/160, local periodical surveys are repeated on the condition of fresh flowing waters at their source and of the surrounding environment together with stagnant fresh waters and seawater to define the geographical, topographic profile, the volume and nature of all pollutant discharges and their effects according to their distance from the afferent bathing areas.

Water restoring plans established by the Legislative Decree 152/99 have the main goal of restoring water ecosystems through managing water resources by preventing and reducing possible impacts on the water environment. This concept of risks prevention underpins the Bathing Directive EC/2006/7.

Point sources of pollution, such as domestic or industrial discharges, are easy to identify and control, but also diffuse pollution sources can have strong contamination effects on streams. In some agricultural areas, for instance, the use of fertilizers and pesticides causes water pollution due to run-off and leaching. Therefore, it is possible to verify the diffusion of the bacterial charge from the surrounding environment to the river through phenomena of surface, sub-surface, deep flow.

Generally, it is defined point pollution source that source related to a well identifiable or definable area. Diffuse sources are linked to an indirect pollution that originates from different sources related to the diverse typologies of land use. Therefore, the correlation between pollution extent and land use is clearly acknowledged.

If, from one side, it is quite simple to discriminate point sources from diffuse sources by observing their geometrical and physical features, on the other side it is not possible to subdivide and classify them clearly, when the focus passes to the identification of the sources affecting the quality of bathing waters.

As an example, the run-off process of surfaces, both in urban and rural areas, is to be included within the diffuse sources of pollution. However, the receiving body (for instance a river) carries the pollutant contribution to its terminal section (the mouth), transforming this diffuse source into a point source, or a considerably reduced source.

If it is considered the urban area (or rural) directly connected to bathing waters, the diffuse pollution source does not change, because there is not the hydraulic downstream effect of water disposal (i.e., hydrographic network).

Considering the difficulty of classifying uniquely a source as point or diffuse, it is suggested the adoption of land use models enabling the evaluation of the pollution loads originated by multiple factors (economic social,

climatic, hydrological conditions) that vary spatially and temporally starting from the input data (e.g., geological, hydrological, on water quality) collected through monitoring activities and mathematical models.

This synergy between different typologies of modelling instruments for the study of the hydrological-hydraulic component and of the marine coastal component, to validate with in-situ observations, improves the knowledge of the ecosystem and of the correlation among determining factors, pressures, and impacts on bathing waters.

3 Workshop on "Observed data and modelling tools for bathing water management": objectives and results

Managing bathing waters requires the definition of shared criteria for the identification and analysis of pollution sources (or pressures) that can impact on the environment and human health. The Bathing Directive (EC 2006/7), mainly focused on prevention, highlights the need of identifying and characterizing the most impacting pressures falling into the profile of each bathing water, and underlines the importance of limiting its influence area, namely the territory portion including all possible pressures causing impacts on that bathing water. This Directive also stresses the importance of forecasting possible pollution incidents to implement management measures aimed at reducing the risk of implications on bathers 'health.

Ordinary monitoring by itself does not fully meet the Directive goals. In particular, it is not sufficient to characterize a pollution source incident and its evolution up to its conclusion. In fact, to respond to these purposes, it is necessary to acquire data on spatial and temporal scales coherent with those typical of the distinguishing processes, the pressures identified as pollution sources (e.g. river mouths, discharges and urban wastewater treatment plants), and the impacted area of the receiving waterbody. To this purpose, the use of observed data and outcome of forecasting modelling in integrated manner enables to characterize pollution sources and understand how and under what conditions (environmental and operational) they contribute to compromising bathing waters quality.

In this context, data and information produced by the Copernicus Programme services or through derived instruments, provide a valid support to solve some criticalities linked to managing bathing waters, already pointed out in the SNPA Guidelines (31/2021).

The aim of this workshop is to present the potential of the products that are available within the Copernicus Programme, to compare the monitoring and modelling experiences done in the different Italian regions, and to collect users' needs for proposing a homogeneous approach to support bathing waters management at national level.

Below is the list of the workshop interventions by expert speakers from research centres and managing and controlling organisations representing different regional areas.

MORNING SESSION - Chairs: Lalli F. (ISPRA), Melley A. (ARPA Toscana)		
Speakers	Intervention title	**Main aspects**
ISPRA **N. Bonora**	Welcome introduction by the coordinator of FPCUP actions	**Nico Bonora (ISPRA)** highlights the synergy between different typologies of instruments for the study of the hydrological-hydraulic component and of the marine coastal component, to validate with in-situ observations, improve the knowledge of the ecosystem and of the correlation among determining factors, pressures, and impacts on bathing waters.
ISPRA **R. De Angelis., I. Lisi**	Managing bathing waters: methodologies for identifying influence area and related pressures	**Roberta De Angelis and Iolanda Lisi (ISPRA)** highlight that for a correct bathing water management it is essential to take advantage of the experience of coastal ARPAs and synergies with the Higher Institute of Health (ISS). They also highlight the importance of the role of environmental risk analysis for safeguarding and preventing human health from natural and anthropogenic degradation of bathing water

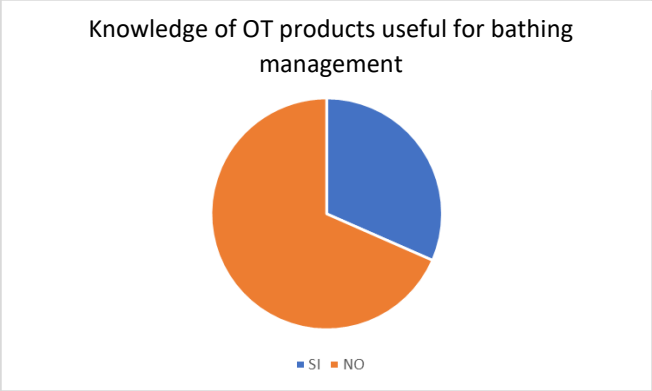
		quality to better comply with the updates to the Bathing Directive (2006/7/EC).
Higher Institute of Health (ISS) – L. Lucentini	Risk analysis of the bathing and recreational waters: state of art and perspectives	**Luca Lucentini (ISS)** points out the importance of the integrated prevention and control based on the PSA (Water Safety Plans) approach. It is a prevention system based on the risk site-specific analysis extended to the entire drinking water supply chain to improve water quality for human health protection and overcoming the limits of the present monitoring system. This aspect represents the core of the recent Directive UE EU 2020/2184 of the European Parliament and Council (recast directive) concerning the quality of waters intended for human consumption. Furthermore, he underlines how the adoption of the risk analysis requires a trans-disciplinary and multi-institutional approach in the frame of the vision presented in the WHO, 2030 Report.
ISPRA **A. Bruschi**	Modelling system and analysis methodology of data developed within the CADEAU project	Antonello Bruschi (ISPRA) presents the results of the CADEAU project, developing a new service for COPERNICUS supporting the Directives for the evaluation of the Italian marine-coastal waters with a specific focus on Upper Adriatic. He points out that linking possible impact sources to the effects surveyed in bathing waters is not simple and this makes it difficult to adopt adequate management measures that go beyond the temporary closure of bathing in case the limits are exceeding for concentrations of Escherichia Coli and intestinal Enterococci (Decree 30 March 2010). He proposes indices derived from modelling results to quantify the potential impact in standard and critical operational conditions (for instance total bypassing of discharges) and in average and unfavourable hydrodynamic conditions.
ARPA Emilia Romagna **A. Valentini**	Modelling supporting bathing management n Emilia-Romagna	Andrea Valentini (ARPA Emilia-Romagna) presents their operational forecasting service to provide indications on possible recurring short-lasting pollution incidents in bathing waters of Romagna coasts. Moreover, he explains the realisation of a database containing the necessary information to define the profile of the regional bathing waters with particular attention to the inventory of the sources that can cause occasional pollution. He points out how the study of the bathing waters quality requires a plurality of actors and competences because of the quantity of information to be systematized. He also underlines how modelling is a very good tool for supporting knowledge and management of bathing waters quality, even if an integration between modelling on land and on sea is required. This implies: • To have good meteorological (rain) and marine (sea level, waves) forecasts • To know all pollution sources at sea • To know all pollution sources on inland • To know all water exchanges in a certain area and be able of showing their behaviour according to the forecast rain • To know how to represent the spatial and temporal evolution of the microbiological pollutants within the hydrographic network (valleys included).

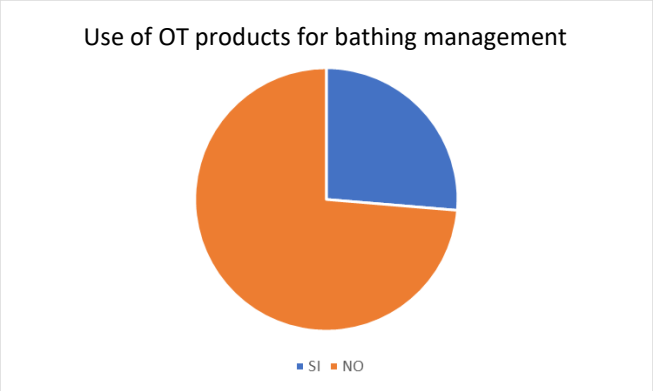
CNR LaMMA **C. Brandini**	The support of modelling for managing bathing waters in Tuscany: opportunities and gaps	**Carlo Brandini (CNR LaMMA)** presents the quality state of waters in Tuscany and the implementation of EU Directives and Regional Conventions for which the supporting use of numerical models of the operational oceanography is required. He stresses the importance of a system of models focused on the study of different components (atmospheric, hydrological, river and urban hydrodynamics, coastal oceanography) and underlines the following critical points: • Some hydraulic parameters are not measured on all river streams of continuous interest • The distribution of rain gauges on coastal areas should be improved • Integration of the observations from all networks (those of the managing bodies included) • Monitoring of the organic load
ARPA Campania **E. Lionetti, E. Piscitelli**	ARPAC's georeferenced database of coastal discharges as management tool for dealing with bathing waters critical issues	**E. Lionetti, E. Piscitelli (ARPA Campania)** explain that, waiting for structural interventions able to reduce possible pollution of marine waters at its source, a careful management of the water network with an active dialogue among all different public stakeholders is needed. They highlight that the ARPAC's georeferenced database of coastal discharges enabled the data territorialization and their insertion in a well-defined and above all unique system of coordinates, and their coherent and wider management and analysis from the spatial point of view. Geodatabases are also the means to make more easily usable information and data resulting from the integration of all available technologies to promptly detect alteration of bathing waters.
ASA (Managing Body in Toscany) **B. La Comba**	Forecasting complexity and correct use of preventive orders of non-bathing in Tuscany	**Barbara La Comba (ASA –Managing body in Tuscany)** reports about the studies carried out in Tuscany and says that the precision required for the application of small-scale forecasting models could be difficult for the specific conditions of the water bodies entering into the sea. It would be desirable a simplified forecasting model to cover coastal areas in an extensive manner and not only designed for specific particularly critical cases. This model could support the evaluation of the incidence at sea of pollution cases and the preventive management of short-term events.
ARPA Emilia Romagna **F. Ortali**	Climate change impacts in managing bathing waters, Summer 2022 case study	**Francesco Ortali (ARPA Emilia Romagna)** describes the use of Sentinel 3 remote sensing images to characterize a meteorological anomaly causing exceeding limits for bathing in July 2021. This anomalous event could not be prevented and the possible hypotheses to explain its causes are an example of exceptional weather, hydrological and marine conditions (very high water temperature for many weeks with values round 30°, prolonged absence of ventilation, scarce water exchange, no dilution of inputs into the water bodies that flow into the sea owing to strong drought) that can have a high impacting effect on the composition of sea waters.
University of L'Aquila **Prof. M. Di Risio**	Urbanisation and quality of bathing waters: regeneration criteria	**Marcello Di Risio (University of L'Aquila)** describes the possible urban regeneration strategies and underlines that they can have positive effects on bathing waters quality according to the sustainable development goals. However, these strategies cannot be exclusively based on forecasting elements of development with low impact (LID), but sustainable development strategies must be accompanied with urban management aspects (mobility, road maintenance, infrastructure upgrade, etc.) involving all stakeholders (development policy makers, local administrators, citizens).

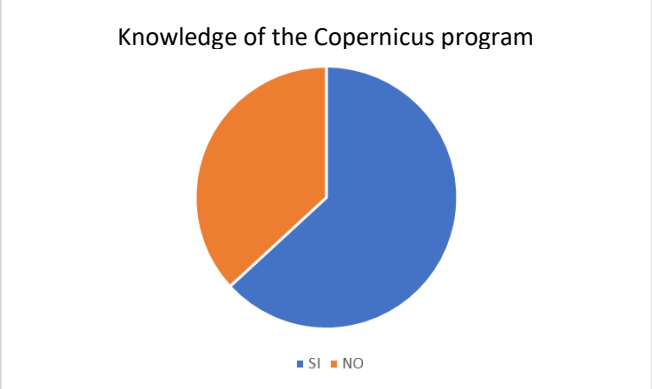
AFTERNOON SESSION - Chairs: Lalli F. (ISPRA), Melley A. (ARPA Toscana)		
ARPA Liguria De Gaetano P., Magrì S.	Modelling supporting environmental monitoring: forecasting blooms of Ostreopsis Ovata in Liguria	**Patrizia De Gaetano and Stefania Magrì (ARPA Liguria)** present the complex phenomenon of Ostreopsis Ovata blooms pointing out how it is difficult to forecast them, because this phenomenon is linked to different environmental parameters that are still not well known. The forecasting results of this phenomenon along the coasts of the Ligurian Sea highlighted the intrinsic limit linked to the structure of the database utilized for the models calibration (unbalanced on the cases of algal blooms absence). In particular, it was found that to identify periods of more probable blooms (therefore monitoring is advisable), the model must be tested through the use of further predictive variables linked to the physical phenomenon, such as persistence of high bloom of *Ostreopsis* ovata.
ARPA Puglia N. Ungaro	Application of numerical, hydro-dynamical, and ecological modelling: case study of Matteotti spillway in Bari and its effect on bathing at the urban beach "Pane e Pomodoro".	**Nicola Ungaro (ARPA Puglia)** shows the results of simulations carried out for the study on the dispersion of wastewater discharged from the pipeline "Matteotti" (Pane e Pomodoro beach, Apulia) that pointed out some problems due to the present data unavailability. In any case, this exercise showed the potential and usefulness of modelling as supporting tool for the institutional activities of ARPA Puglia, from those concerning the monitoring of water quality to those linked to the control on authorized works and activities at sea and along the coast, as well as during possible environmental emergencies.
ARPA Lazio L. Aguzzi, C. Cossio	The experience of monitoring bathing water in Latium	Laura Aguzzi and Caterina Cossio (Arpa Lazio) present the results of monitoring carried out along the coast of Latium and highlight the following criticalities that could induce a complete revision of the bathing waters profiles: • need of increasing environmental information (pressures) and of the tools needed for studying them (forecasting modelling) • need of revising the protocols related to the possibly toxic algae to define a correlation between total phosphorus and cyanobacteria concentrations and better plan sampling of *Ostreopsis ovata*.
ISPRA I. Lisi	ISPRA and its models: a numerical almost hydrostatic method for studying coastal flows	**Iolanda Lisi (ISPRA)** describes the models developed in ISPRA to study complex coastal phenomena and observes that the 3D models taking into accounts currents and waves can enable in-depth analyses on the correlations between pressures and impacts caused by the incidence of punctual sources input, both on terms of bacterial contamination and other correlated factors (like the temperature variation in water column) that can alter the natural balance between the abiotic and biotic components. The implementation of the model for the decay of Escherichia Coli (e.g Chan, Thoe & Lee) is ongoing.
ROUND TABLE: What can be improved? Towards a shared and generalizable method. **Chairs: Bruschi A. (ISPRA), Bortone G. (ARPA Emilia Romagna)** Dialogue between the different actors in the bathing waters management and the mathematical modelling community is not always easy. Therefore, we do not often have all useful information in the implementation phase of models, and this affects their accuracy. Monitoring of water purification plants is to be increased to improve forecasts necessary for risk analysis. What makes the situation also critical is the fact that bathing water management involves a very large territory that requires a lot of information on inland and marine areas.		

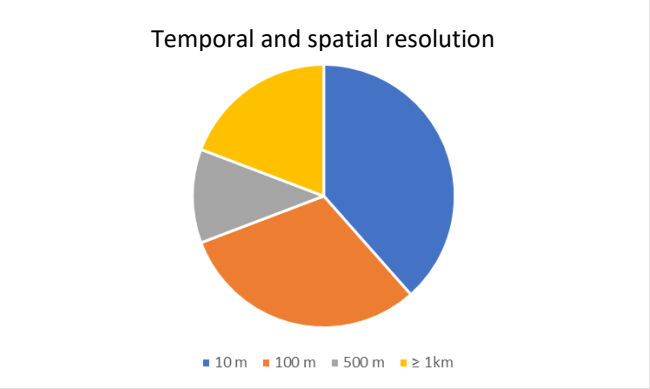
To systematize the local case studies, it is also necessary to consider that the local solutions cannot be always generalizable in other contexts.

Main questionnaire results









4 Explanation of the obtained progress

The increasing attention of management international and national policies and stakeholders for checking, controlling and preventing environmental critical issues on bathing waters has brought out over the years the multiple benefits that can arise from the integrated used of forecasting models coupled with data originated by Earth observation systems (EEA 2016; WHO 2003, 2006, 2017, 2018, 2020)..

The implementation of these tools allows to facilitate the selection and implementation of measures by means of:

- a better knowledge of territory;
- the evaluation and prevention of possible environmental and hygienic-sanitary effects related to quality alterations of bathing waters;
- the selection of managing targeted measures (in terms of localisation and necessary duration) based on a method oriented to the prevention of exposure risks rather than based on conventional retrospective control.

The comparison between different experts belonging to the scientific community and local managing bodies differently involved in bathing waters management highlighted operational critical issues on the integrated used of atmospheric, hydrological, and coastal dynamics data. These data are obtained by different acquisition platforms at different spatial and temporal scales. Specifically, it is stressed the study of the processes underlying transport of pollutants (e.g. diffusion, dispersion, deposit, and decay phenomena) released into a waterbody from diffuse or punctual sources of bacterial and chemical (nutrients) contamination.

It was pointed out the need of setting uniform criteria in line with the contents of the Directive EC/2006/7, of the Legislative Decree 116/2008, and of the Ministerial Decree 30/3/2010, distinguishing among the following purposes of interest:

- identify and characterize those pressures representing relevant contamination sources in relation to the observed and/or potential critical points in the influence area of a bathing water;
- predict short-lasting pollution events and possible anomalous situations also through early-warning systems and characterize the process evolution in the impacted area;
- support correct positioning of study and monitoring points;
- compile and update the water profile as the tool intended to ease and direct the planning of the management measures concerning the identified critical scenarios in relation to the consistence and recurrence of limit values of faecal bacteria and other indicator parameters of water quality established by law.

The importance of defining the studies minimum requirements in relation to the above-mentioned purposes and typology of the observed/expected criticalities is underlined.

Below the structure of a modelling system usable for support to the management of receiving marine-coastal water bodies including one or more bathing waters is described.

Bathing waters management has its main goal in the protection of human health from risks caused by poor quality of waters. To support the study of risk factors and define the necessary management measures, a modelling system must be able to facilitate the achievement of the following main objectives:

- identification and analysis of pressures (contamination sources) to be considered as a possible future cause of alterations in the quality of bathing waters;

- delimit, characterize, and forecast the area affected by dispersion of faecal pollutants (E. Coli, intestinal enterococci,), reproducing their variability on different spatial and temporal scales, considering the specific behaviours of the examined pollutants (e.g. decay factor due to inactivation effects due to violet rays, salt concentration and water temperature);
- identification of critical scenarios that could have a negative impact on the quality of bathing waters in relation to the different meteorological forcers (medium or standard, extreme or critical) influencing run off amount (river flow, operation and drains malfunctioning) and the hydrodynamics of a site (e.g. poor water exchange);
- direct programming and targeted and timely implementation, in the affected areas for the necessary duration, of management measures (strategic and operational) able to requalify the system.

Observational and modelling methods to manage bathing waters can also be implemented in integrated mode for:

- the preventive analysis of effects (through diagnostic, scenarios-forecasting approaches), aimed at identifying and predicting the causes that determine bathing water pollution starting from the climatological analysis according to a statistical or probabilistic classification, and the reconstruction of events observed in the past;
- real time forecast aimed at the timely implementation of alert systems and measures of management/mitigation starting from the most recent available observations.

The logical frame at the basis of the multi-scales and multi-models of the modelling system proposed for the study of the influence area for bathing water management is recommended, as it follows that of the DPSIR model (*Driving forces, Pressure, State, Impact e Response*), i.e. the logic of providing and updating datasets useful for improving the knowledge of the system and of the correlation between drivers, pressures and impacts at different scales.

The possibility of investigating phenomena of interest by reference to multiple spatial and temporal scales, makes the indications provided for implementation of the modelling system valid and generalizable for the different territorial areas (contexts) where a generic water body containing bathing water (marine, lake and river environment) can fall into.

What reported in the guidelines published by WHO in July 2021 and USEPA in 2007 to better support the understanding of pathogens in waters could be also useful for the quantitative evaluation of the microbial risk (QMRA), that enables the conceptualisation and quantification of pathogens sources and barriers, included dilution and transport more in general. QMRA combines scientific knowledge on presence and nature of pathogens, their potential destiny in the water cycle, the routes of exposure and the consequent effects on health, as well as the effect of natural and artificial barriers and the adopted hygienic measures. All this knowledge is integrated in a unique evaluation, enabling a coherent, proportioned, transparent, evidence-based management of the risk of transmission.

This methodology presents excellent potential; nevertheless, it has still some limits because of insufficiency and uncertainty of data available in scientific literature and the high competence of the experts called to validate and elaborate information and data considering that the application of inadequate models or criteria could imply the adoption of inadequate prevention and control measures to protect the exposed population. Modelling applications could at least fill the gaps related to the study of contamination, strengthening in this way a possible methodology of risk evaluation that will be adopted in next water safety plans also recommended by WMO (WHO, 2021) for bathing waters.

Key points are reported on how modelling can support monitoring optimisation and adoption of targeted management procedures in the frame of a bathing water management programme articulated in phases:

1. ordinary (routine) phase of monitoring/management
2. attention/alert phase
3. emergency phase.

The focus is on the ordinary (routine) monitoring/management phase. The use of modelling in the routine management of bathing waters can be a valid support to the monitoring programme, enabling:

- the delimitation of the area of influence
- critical areas attributable to the occurrence of short-term events
- critical areas attributable to the occurrence of anomalous situations
- the identification (where it is possible) of management modes of short-term pollution cases, etc.

In general, the implementation of modelling activities in this phase can provide a valid support to the identification and definition of bathing waters profiles, as it allows to evaluate the influence radius exerted by each discharge on the portion of sea in front. Alike, it can be of help for the identification and localisation of the monitoring points that preferably should be in the zones most exposed to high microbiological loads.
In this phase multiple scenarios of simulation can be reproduced by using climatological and short and long-lasting realistic modelling approaches.
A good modelling simulation is based on knowledge and awareness of the main processes and dynamics on land that have (or can have) impacts on short-lasting phenomena of microbiological pollution in marine-coastal areas.
A preliminary fact-finding phase is paramount to collect the necessary information to characterize adequately the influence area on land that insists on the considered sea portion, identifying all possible pressure sources and their variability depending on environmental conditions.
This is often possible thanks to the collaboration among working groups with interdisciplinary competencies and water service management bodies able to provide a qualified technical-knowledge support on drain operating modes.
In particular, the characterisation of discharges into the sea (flows and concentrations) is fundamental, as the duration (i.e. the persistence in hours), the intensity and extension of the portion of sea affected by pollution following short-lasting pollution events differ greatly in discharge typology and underlying area of interest.
Once identified those pollution sources representative of the area, an arbitrary number of simulations can be conducted. It is important for this scenarios simulation to consider as many cases as possible of climatic and meteo-marine conditions (precipitations, wind, waves, currents, river floods, cloud cover, high temperatures, etc.), so to create a scenarios map that is representative and exhaustive of the various critical issues to be verified.

In this phase, it can be of help to carry out a good modelling study able to identify management modes related to closing/opening of bathing waters. In this context, models can be used to identify the episodes duration with respect to certain triggering events (precipitations, opening of flood drains, flood spillways of purification plants, etc). Consequently, there can be local authorities able to adopt preventive seasonal orders on the basis of this modelling study, as sewerage and hydraulic systems are enough controlled and delimited, while in other places this management mode is impossible to be practiced for the large territorial extension of the influence area and the consequent environmental and anthropogenic dynamics.

Bibliography

EEA, 2016. European water policies and human health. Report No 32/2016. EEA, 2020. Bathing water management in Europe. Successes and challenges. Report No 11/2020

WHO, 2000. Monitoring Bathing Waters - A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes. Published on behalf of WHO by: F & FN Spon. Edited by Jamie Bartram and Gareth Rees, 311 p. ISBN-0-419-24390-1.

WHO, 2003. Guidelines for Safe Recreational Water Environments Coastal and Freshwaters, vol. 1, World Health Organization, Geneva, Switzerland (2003). 253 p. ISBN: 9241545801

WHO, 2006. Guidelines for safe recreational water environments. Swimming pools and similar environments, vol. 2,. World Health Organization, Geneva, Switzerland (2006). 146 p. ISBN: 9241546808

WHO, 2017. Support to the revision of Annex I Council Directive 98/83/CE on the Quality of Water Intended for Human Consumption (Drinking Water Directive).

WHO, 2018. Recommendations on scientific, analytical and epidemiological developments relevant to the parameters for bathing water quality in the Bathing Water Directive (2006/7/EC). FINAL REPORT 11 June 2018, 96 p.

WHO, 2020. Global strategy on health, environment and climate change: the transformation needed to improve lives and well-being sustainably through healthy environments. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO.