Part C

WATER JOINT PROGRAMMING INITIATIVE

WATER CHALLENGES FOR A CHANGING WORLD

2018 JOINT CALL
Closing the Water Cycle Gap

“Supporting tools for the integrated management of drinking water reservoirs contaminated by Cyanobacteria and cyanotoxins”

“BLOOWATER”

No	Participant organization name	Country	Short Name
1	Italian National Agency for New Technologies, Energy and Sustainable Economic Development	Italy	ENEA
2	Polytechnic University of Marche	Italy	UNIVPM
3	Norwegian Institute for Water Research	Norway	NIVA
5	Uppsala University	Sweden	UU

1. EXCELLENCE

1.1. Introduction

Water has a broad impact on all aspects of human life including health, food, energy, and economy. In addition to the environmental, economic and social impacts of poor water supply and sanitation, the supply of raw water is essential for people's health. Dangerous levels of the cyanobacteria derived toxins caused Toledo, Ohio, to shut down the drinking water supply of 500000 residents for three days in 2014.

Cyanobacteria, also known as blue-green algae, are photosynthetic bacteria and common members of the plankton in both marine and freshwater habitats. Under favourable environmental conditions, they can quickly multiply and form blooms in water and release toxic secondary metabolites during their senescence and death. These metabolites have been found to be dermatotoxic, hepatotoxic and tumor promoters, and recently they have been connected to neurodegenerative diseases. Occurrences of cyanobacterial blooms are increasingly detected in lakes and reservoirs throughout the world due to anthropogenic emissions of nutrients and climate change. In some countries toxic cyanobacteria represent an increasing and serious environmental hazard for livestock and wild animals, while humans may be seriously affected during outdoor swimming or via contaminated water supplies. Cyanobacteria occur in waterbodies in all 29 European countries. The range of waterbodies in which Cyanobacteria occur in Europe includes fresh waters (natural lakes, rivers, ponds, man-made reservoirs and canals) and brackish waters (the Baltic Sea, estuaries, and lagoons). They include high resource and amenity waters, including drinking water sources, waters used for livestock watering, aquaculture, recreation and tourism, and designated wildlife or conservation reserves. The presence of toxins from cyano-Harmful Algal Blooms (HABs) in drinking water reservoirs may represent serious health risks for the human population.

The World Health Organization (WHO) set a provisional guideline limit of 1 μg L^{-1} for the presence of microcystin-LR, one of the most harmful cyanotoxin known in drinking and recreational waters (WHO, 1998). To further assess cyanoHAB risk the , WHO recreational guidelines set thresholds of cyanoHABs into three risk categories: low, moderate, and high-risk bloom area.

Many research groups make efforts to plan effective risk management strategies and to elaborate risk assessment evaluations considering all the possible routes of exposure for the human populations

Therefore, in the coming years it is expected that increased i research in this field will be neecded. In particular, it will be necessary to develop integrated management strategies to address the problem of the cyanoHAB blooms.

1.2. State-of-the-art and relation to the work programme

The present and possible future cyanobacterial bloom expansion can be attributed mainly to nutrient over enrichment in watersheds with relevant human activities and changing climatic conditions. Over the years, various field studies have been conducted for understanding the diverse interactions among physico-chemical and biological variables leading to the proliferation of cyanobacterial blooms in freshwater bodies.

According to Wells et al. (2015), there is a strong need to outline clearly what currently is known (and not known) about the environmental conditions that favour the initiation and maintenance of different types of cyanoHAB events, and how sensitive those key parameters are to changes in the climate system.

Increased anthropogenic nutrient inputs is one the main drivers of cyanoHABs. Additional drivers known to promote cyanoHAB growth included stratification and associated changes in temperature, as well as changes in the frequency and timing of extreme weather events (Urquhart et al. 2017). Controlling CyanoHABs may be more challenging in the future due to these effects. For example, the examination of 143 lakes along a climate gradient in Europe and South America (Kosten et al., 2012) indicated that increased water temperature led to a gradual rise in the frequency of occurrence of Cyanobacteria. Non-linear state changes in lake ecosystems are difficult to predict and extremely difficult to reverse after they occur (Scheffer et al., 2001). If the same kind of response trajectories occur for harmful cyanobacterial blooms, nutrient controls become much more crucial as increasing atmospheric temperatures approach these critical thresholds. While forecasting the effects of climate change is a challenge, especially on local and regional scales, the high probability that future climatic conditions will favour bloom formation poses an added challenge to developing effective mitigation strategies that consider both nutrient

and climate drivers. Interactions between warming, changing hydrology, agricultural and industrial expansion, and nutrient delivery to aquatic ecosystems will require new approaches to managing CyanoHABs. Nutrient-growth threshold responses for CyanoHAB taxa likely will be altered as physical (e.g., temperature) and geochemical (e.g., nutrient fluxes) controls on these thresholds also change, resulting in moving targets in our quest for long-term CyanoHAB control (Paerl et al., 2016).Several monitoring approaches and predictive models have been developed to provide accurate and timely information regarding the development of cyanobacterial bloom in the water bodies (PROGNOS WATER JPI project, http://prognoswater.org/), and these models have been tested and developed at Lake Erken Sweden, a study site in BLOOWATER. Given the long and extensive record of automated and traditional monitoring at this site that can be used for model calibration and validation, BLOOWATER will continue the testing and development of models already used the JPI Water PROGNOS, and JPI Climate WATExR projects, but with a much stronger emphasis on the predicition of CyanoHAB blooms.
Predicting future scenarios is a major challenge to ensuring protection of human health. It is necessary to define the potential risk associated to cyanobacterial presence in different environments in relation to exposure routes. As a consequence, it will be possible to identify the appropriate management strategies to be adopted to protect water resources, mitigating the negative ecological and biogeochemical impacts and economic losses both in the short and long run. It has been estimated that only in the United States cyanobacterial blooms result in losses of recreational, drinking and agricultural water resources that are worth over $ 2 billion annually. A lot of studies have been published on the occurrence of cyanobacteria and their ability to produce cyanotoxins in surface waters; they have been extensively reviewed in dedicated publications on both ecological and toxicological aspects. According to the main literature, in Europe, dedicated treatment plants to remove cyanotoxins do not presently exist but some tests at laboratory scale are reported by the scientific literature. In particular conventional treatments such as coagulation, flocculation and filtration are reported, but their use my cause cells breaking and cyanotoxins release. Coagulation and flocculation, moreover, require the use of chemicals such as Aluminum sulphate. In the recent years, the complexation-ultrafiltration technique has been shown to be a promising technique for removal of pollutants from water. In particular the *polymer enhanced ultra filtration* (PEUF) using natural polymers such as Chitosan can be a novel alternative to treat waters polluted by cyanobacteria reducing both, the equipment and the treatment costs.

1.3. Objectives and overview of the proposal

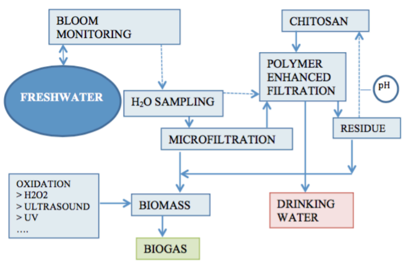
The main objective of the BLOOWATER project is to produce informational resources for Public water supply systems and Agencies to prepare and respond to the risk of the cyanotoxins in drinking water. Practically the project proposes innovative technological solutions that are aimed to develop a methodological approach based on the integration of monitoring techniques and treatment of water affected by toxic blooms (multiple barrier approach). BLOOWATER will integrate innovative methodologies into a multisensor platform to improve water quality through the development of effective low-cost and functional measures into prompt and opportune intervention procedures for efficient and sustainable management of the water resource.
The project intends to develop and implement methods to treat freshwater with more efficient processes (PEUF) and will definine diagnostics protocols through the integration of innovative techniques for water monitoring, aimed at creating forecasting models and systems of surveillance and early warning of toxic blooms. These will allow immediate actions such as opportune potabilization treatment.The development of specific algorithms will allow advanced processing of the different spectral and toxicity data to produce predictive and early warning models of toxic blooms useful for stakeholders and in particular for treatment plant operations. Source water and system observations can inform a Water system's decisions about if and when to start cyanotoxin monitoring in raw water, when and how to adjust treatment plant operations and when to communicate with external stakeholders and the citizens. Historical series (i.e. sampling locations and frequencies) are useful to include in a ICT platform. In particular can be valuable to a water system (and nearby systems) for determining if and when the water system is vulnerable to cyanotoxins.
Concerning the treatment processes, the BLOOWATER solution proposes a polymer-enhanced ultrafiltration (PEUF) to remove both, Cyanobacteria and cyanotoxins from freshwater. The ultrafiltration (UF) is a promising process to produce qualified drinking water (In Norway, NF-based treatment is frequently used for the drinking

water production) and requires less energy compared to commonly used nanofiltration (NF). The application of ultrafiltration for drinking water production has undergone accelerated development during last years. The main limit of the application is related to the membrane fouling which usually causes higher operative and maintenance costs. Conventional chemical and physical pretreatments (e.g. coagulation, adsorption, and pre-oxidation) could decrease the fouling effect and can be used to previously remove particulate inorganic or organic suspensions and also dissolved organic substances.

The majority of commercial water-soluble polymers, used as coagulants, derives from petroleum-based raw materials synthesised using processing chemistry. Today, there is growing interest in developing natural low-cost alternatives to synthetic polymers. Between these reagents, the Chitosan is obtained from chitin (natural waste from shellfish) and is cheap, abundant ecological and furthermore it is not harmful to human health.

The enhanced ultrafiltration process (PEUF) could be carried out by coupling the UF technology with chitosan polymer dosage. Biopolymers such as chitosan or other polysaccharides were chosen for complexing the toxins before filtration. The functions of the toxin-polymer complexation are to increase their molecular weight and their size. The size of the complex has to be larger than the pores of the selected membrane so the complex can be retained, while permeate is then purified from the toxins. The efficiency of the PEUF process treatments is strongly associated with many parameters the type of the polymer dosage, dosing modes (continuous or intermittent) mixing ways, temperature, water impurities (colloidal or dissolved, organic or inorganic), solution environment (solution pH and ion strength), and characteristics of the membrane (membrane charge, hydrophobicity, and surface morphology). Advantages of PUEF over the other conventional technologies are the low energy requirements involved, the very fast reaction kinetics, the high selectivity of separation and production of high quality water.

Finally, disinfectant/advanced oxidation processes (AOP) is usually considered as tertiary technology to obtain the final drinking water quality. Further, the conventional ozone process usual as AOP solution in the water supply treatment schemes, the pulsed UV (PUV) represents an innovative disinfection solution. Whether pulsed UV light is more bactericidal than continuous UV is still debated. PUV efficiencies are mainly due to the combination of light intensity and length of the exposition peaks comparing to the germicidal removal of traditional continuous UV light. Following the main project actions, the proposed integrated approach basically involves the following steps: monitoring by remote and lab systems, treatment with natural polymers, control and distribution of drinking water.



The proposed monitoring/process scheme

1.4. Research methodology and approach

This chapter describes the methodology adopted to review actions and technical problems envisaged during the design of the project. The work plan of BLOOWATER includes five operational work packages:

WP1.MONITORING SYSTEM DEVELOPMENT (WP coordinator: ENEA; PPs involved: UU)

WP1.1 Implementation of Cyanobacteria monitoring system.

Monitoring bloom occurrences, composition, frequency and intensity provides important indicators of degraded water quality. BLOOWATER proposes a monitoring strategy based on a tiered approach, combining remote and proximal sensing technology with in situ aquatic monitoring. In this WP we will test the possibility to integrate data from satellite and aerial platforms to improve resolution and flexibility on various spatial and temporal scales.

Additionally, in situ sampling and spectrophotometric and molecular analyses will be essential part of diagnostic procedure to confirm developing cyanobacterial bloom species only in the areas identified by remote and proximal sensing.
In these last years we combined use of Chl a and PhycoCyanin (PC) in vivo fluorescence by diagnostic and monitoring system based on a set of different instruments, commercially fluorometers, (Cyanowatch and Phyto-Pam) and instrument prototype developed in ENEA for water monitoring. They attempt to improve measurements of chlorophylls and accessory pigments and organic compounds contributing to assess phytoplankton physiological/nutrient status, provide basic structural characterization of phytoplankton community and determine the change in the phytoplankton community composition.
To increase the efficiency of the monitoring system we will apply an unmanned aerial vehicle (UAV), instrumented buoys and surface vehicle. The remote sensors mounted on the UAV (RGB and the hyper-spectral cameras) will capture images at a certain frequency during the flight.
The Cyano-HABs will be recognized based on the obtained images and by using optimized algorithms the CHABs distribution will be mapped. Cyanobacteria floating at the water surface show unique reflective wavelength signals from those of water. These characteristic signals can be easily captured with the cameras featuring RGB bands and discriminated using the algorithms developed by our project team.
The variability in vertical migration pattern, distinctive trait of temporal and spatial distribution of Cyanobacteria, can be significantly affected by many environmental factors, such as wind, temperature, and light intensity. Therefore, the signal to noise ratio of the Cyanobacteria detection can be significantly improved with a proper understanding of the their dynamic nature. The use of UAVs in BLOOWATER will allow integrating the unique wavelength signals and an understanding the dynamic nature into an effective RBG detection platform. In this way, it will possible achieve maximum information acquisition efficacy to achieve early and timely cyanobacteria detection.

WP1.2 Data Collection of Cyano-HABs
Currently, very few time series of Cyano-HAB data describing annual phytoplankton cycles are available in the literature. Current spatial and temporal ranges of HAB species will most certainly change under future climate scenarios. Some regions clearly will be affected more by global warming than others, but high latitudes will experience the greatest absolute and relative warming. The study aresa choosen in Sweden and Italy are included in national water quality programs, providing important datasets for investigating global changes in the prevalence of HAB. Lake Erken and Mälaren in Sweden and Garda and Vico Lakes in Italy are pilot areas selected, where the BLOOWATER monitoring system will be tested under real conditions of application. The collection of historical series and in situ data on a real-time basis of water bodies with different geographical and ecological characteristics will improve accuracy of regional models allowing to develop new algorithms for other areas or other HABs.

WP1.3 Design of a Digital Database by using commercial software that can assist Public water operators in understanding critical factors that contributes in cyanoHABs formation. These data will be utilized for the ICT and DSS development (WP2.1 and WP4.1) much as is done with meteorological sensor networks and weather forecasts.
Deliverables
M9 choice and definition of the main functional parameters of the project, integration between acquisition systems (ground-air), methodology development/implementation and equipment arrangement/linking systems.

M3 identification of the study areas to be investigated extensively
M6 database obtained by applying commercial software

WP2 DEVELOPMENT OF BLOOM FORECASTS (WP coordinator: UU; PPs involved NIVA, ENEA)

The development of cyanobacteria blooms is complexly controlled by the interaction of multiple environmental factors that affect the availability of light, and nutrients, as well as the temperature and stability of the lake water. Furthermore, the actual impact of a bloom will depend not only the increased growth of the cyanobacteria, but also their local distribution and toxicity. The purpose of this work task is to produce forecasts of the probability of increases in cyanobacteria biomass. These will provide a warning of the potential for cyanoHAB formation that will allow water utilities to increase surveillance and prepare for potential increases in water treatment. Two methods of predicting cyanobacteria blooms will be evaluated by this WP: Predictions based on mechanistic modelling and predictions based on automated machine learning algorithms.

WP2.1 Testing of mechanistic water quality models for predicting cyanobacterial blooms Months 2-23.

In this WT we will test the ability of mechanistic water quality models to predict the occurrence of cyanobacteria blooms at the case study sites used by BLOOWATER. The models and approach followed will be similar to that undertaken in the PROGNOS project. However, here we will specifically focus on the predication of cyanobacteria making use of the historical records of cyanobacteria biomass, and the automated proxy measurements of cyanobacteria collected at the case study sites. We will make use of the FABM modelling system (Bruggeman and Bolding, 2014) that allows the coupling of the one dimensional hydrodynamic model GOTM (Burchard, 2002) with different water quality models we anticipate use of the SELMA model based on ERGOM (Neumann, 2000), but modified for use in PROGNOS. This model simulates a single cyanobacterial functional group that is defined by characteristics such as nitrogen fixation, large size and positive buoyancy. This single generic group of all cyanobacteria, can be used as an general indicator of the potential for cyanoHAB blooms to form, and we will produce probabilities of the cyanobacteria blooms based on this generic group. If needed we may also evaluate the use of algorithms describing phytoplankton function groups in the PROTECH model (Reynolds et al., 2001). These can describe the growth and behaviour of several different cyanobacteria groups. Inputs to the model include the meteorological data needed to force the GOTM hydrothermal model, and in the inputs of water dissolved and particulate N and P to the lake. In order to calibrate and verify model performance we will also need to compare model simulations with measured values of water temperature, dissolved oxygen, lake N and P concentrations, chlorophyll concentration as well measures of cyanobacteria biomass (microscopic counts and phycocyanin fluorescence. Historical records of all needed forcing and calibration data will be available at the case study sites, and the monitoring platform developed by BLOOWATER will also provide valuable data for model testing and calibration.

WP2.2 Testing of alternative methods of predicting cyanobacterial blooms based on machine learning algorithms. Months 5-28

Machine learning uses a variety of methods (ie neural networks, random forest) to predict phenomena based on the input of time series of drivers that could be of potential importance. In the case of BLOOWATER these drives would be the same meteorological data and nutrient inputs that are used to force the mechanistic model described above, and also the automated measurements of lake water quality that will be incorporated into the monitoring platforms developed by BLOOWATER (ie water temperature, chlorophyll fluorescence phycocyanin fluorescence dissolved oxygen etc.). The value of machine learning methods is that they can determine predictive algorithms without prior knowledge of the lake system or the relative importance of the input data. They can also merge and make use of information that would be used to both force and calibrate more traditional models as described above The disadvantage will be that they provide little mechanistic understanding of the processes affecting cyanobacteria, and that the algorithms developed will be site specific.

WP2.3 Developing model workflows Months 18-34

The ability of both traditional water quality modelling and machine learning techniques to predict the occurrence of cyanobacteria blooms based on the input of short term meteorological forecasts and sensor data collected in WP1 will be evaluated by hind casting simulations at all case study sites identified in WT 1.1, where historical measurements of both the model inputs and cyanobacteria biomass are available. Following this we will develop model workflows that will allow the developed models to run up to present conditions, thus providing optimal initial conditions for the mechanistic approach or the most complete data set for the machine learning approach. Short-term weather forecasts will then be used to drive the models to make future predictions of cyanobacteria biomass. Nutrient inputs will estimated using simplified watershed models driven by air temperature and precipitation. Uncertainty in the predictions will be accessed by accounting for uncertainty in the weather forecasts, and by perturbing key model parameters. To demonstrate the feasibility of the developed work flows for use in an integrated management tool we will make hindcasted forecasts at one or more of the case study sites. These will use historical weather forecasts to produces cyanoHAB forecasts over a time period where historical data on cyanobacteria abundance are available. We will then assess the usefulness of the cyanoHAB forecasts by comparison with actual measurements of cyanobacteria biomass.

Milestones
M3 Final decision on case study sites made. Data needed for model forcing and calibration collected and collated.
M9 GOTM hydrothermal model setup and calibrated for all case study sites.
M18 SELMA water quality model setup and calibrated for all case study sites.
M21 Machine learning algorithms tested on all case study sites
M24 Model workflows produced that will make short-term forecasts of the probability of cyanoHAB blooms.
M30 Demonstration of potential forecast system

Deliverables
M6 Publicly available data archive of all data used to force and calibrate lake water quality models
M24 Manuscript to be submitted for publication comparing the simulations of cyanoHAB blooms using mechanistic models and machine learning methods.
M32 Manuscript to be submitted for publication describing the BOOWATER cyanoHAB forecasting system.

WP3 TREATMENT PROCESS COMPARISON (WP coordinator NIVA; PPs involved: UNIVPM, ENEA)
General objective of WP3 Treatment Process Comparison: to study, develop and validate sustainable and efficient technologies for the treatment of water affected by cyanobacteria toxicity.

WP3.1 Definition of specific technological treatment solutions functional to the different scenarios.
Specific objective WP3.1 To assess performances and economic comparison between different conventional technological solutions for toxic bloom reduction
NIVA/UNIVPM will review technologies for the treatment of water contaminated by cyanobacteria and cyanotoxins in the drinking water production. Different conventional technological solutions currently used in drinking water treatment plants (DWTPs) such as NF, enhanced coagulation, adsorption onto Activated carbon, ozonation/biofiltration will be evaluated and compared for the treatment of surface waters in terms of algal blooms control and cyanobacteria toxicity minimization. Data of efficiencies, operative parameters and costs will be summarize also considering the initial water characteristics and the bacteriological toxicity. Performances and economic assessment will be used for comparison analysis and benchmark between the BOOWATER Solution and those collected from the literature.

WP3.2 Bench Scale Testing of PEUF and reference technology.
Specific objective WP3.2 To determine in laboratory scale the treatment efficiencies and the main operative parameters of some innovative technologies
Laboratory tests (5 L of Volume) with surface water will be carried out to determine the toxicity reduction from cyanobacteria by using PEUF. The Chitosan polymer (or others such as Xanthan) will be added at different dosages and contact times to enhance the cyanobacteria toxins reduction. The settled treated waters will be filtered to predict ultrafiltration effects. Macropollutants will be characterized in the main streams of the different tests. Provisional operative parameters, performances and eco toxicological data will be collected to support the following field validation and to determine the optimal flow scheme of the Bloomwater solution. The surface water will be collected from the Lake Vico (VT-Italy). To be able to do a "direct" comparison with the tests proposed by NIVA, NIVA could provide selected algal strains for testing both in Italy and at NIVA. We will then be sure to test the same strains and potentially also the same toxins, and we could test a broader range of toxins. In parallel to PEUF tests, NIVA will carry out a lab-scale NF experiments as a reference to currently applied method in DWTPs. The effectiveness of the PEUF will be experimentally compared to that of conventionally used NF. The results

obtained in the lab-scale NF will be validated with the selected full-scale DWTPs in Norway using NF. The algae culture collection will be used during the tests to verify performance of the different treatment solutions against a well identified cyanobacterial stains.

WP 3.3 Processes design, development and field validation of the promising water treatment technologies will be performed by the project partners

Specific objective WP3.3 To validate in demonstrative scale the optimal flow scheme for enhancement the removal of cyanobacteria toxic compounds.

From the results of the bench activities, the optimal flow scheme will be designed and developed. The process validation will be carried out in demonstrative scale (TRL 5-7). The pilot system will be installed in the demo site of Lake Vico and will treat 0.2-0.5 m3/d of surface water. The pilot system will consist in two main units: coagulation and flocculation reactor with polymer of chitosan dosage and ultrafiltration unit. The pilot will be equipped with Programmable Logic Controller (PLC) that may be used in remote control. The control tool will be associated to the on-site risk assessment developed from modelling-provisional analysis on the basis of WP1 results to select the best operative actions. The chitosan dose, the toxin accumulation and the effect of polymer pre-treatment in the UF fouling mitigation will be validate in the coagulation-flocculation reactor. The PEUF long term operation will be performed at different specific fluxes also to evaluate the cyanobacteria reduction in demonstrative scale. A deep investigation on membrane biofouling over the full length of UF membrane to predict the fouling caused by algae and algal organic matter will be performed to reduce maintenance costs. Tests of Bio Methane Potential (BMP) will be carried out to determine the possible biogas production from residual concentrate flow of PEUF. The final PEUF effluent will be tested in laboratory scale by using pulsed UV with LED lamps at different light intensity and peaks duration to determine the bacteriological reduction and the disinfection doses in comparison with conventional continuous UV treatment or ozone technology.

The cyanobacteria removals, the main macropollutants characteristics and the final water quality will be analysed to be compared with the drinking water standard. Finally, some emerging pollutants will be analysed (i.e. pharmaceutical for human consumption compounds) in the main units of the flow scheme to determine the possible secondary effect of the PEUF configuration in the pharmaceutical adsorption and removal. The obtained performances will be linked with the technological scenario summarized in the WP3.1 and the experimental results will be the input data for the WP4 activities.

Deliverables (brief description and month of delivery)

D3.1 Practical report on data performances and economical assessment of conventional technologies for cyanobacteria reduction (M8)

D3.2 Scientific report on lab tests results and provisional operative parameters to design the demonstrative pilot (M20)

D3.3 Scientific report on long-term validation and process optimization in real environment to enhance adsorption and removal of toxic cyanobacteria compounds (M32)

WP4 DECISION SUPPORT SYSTEM DEVELOPMENT (WP coordinator: UNIVPM; PPs involved: ENEA, UU, NIVA)

WP4.1 Country data acquisition on the water cycle management with special focus on the Country needs for the pilot action and social mapping of relevant stakeholders.

The first action will start from the definition of a comprehensive set of data to be collected that are needed and are suitable to the development of the database, the GIS and the DSS (data and information gathering, identification of software tools, field survey, etc.).

Guidelines on data collection, acquisition and insertion will be realized for harmonizing the data coming from different countries (Skype-partner's meetings). On this basis the data will be collected by all partners under the coordination of ENEA, focusing on the data concerning the priority area (and pilot action site) identified for each country (surface of the phenomenon, evolution time, etc). An identification of the stakeholder (social, administrative, political, technological, etc) that operate in the drinking water management will be compiled.

A guideline on data collection and management (heading to the harmonization and utilizable beyond the scope of the project) will be produced and implemented with the country data set of on water resources management at local, national and international level will start. The aim is to ensure the future sustainability of the project by involving and informing in the project all institutional, private and international actors that would be crucial for the future local water management.

WP4.2 Realization of a database (db) on the drinking water management.

Setting-up of a specific and dynamic reference database: definition of the structure of the database and development of a database application based on the commercially available technologies to be automatically fed with the data collected during the task 4.1 application. The db will be made and organized following the instructions and indication reported in the 4.1 action. Moreover the data collected in action 4.1 will be integrated with data collected at European basin level in order to make available a set of integrated data having relevance and comparableat the Regional level. In particular a link with the Harmful Algal Events Database (HAEDAT) will be developed. Moreover links to national risk management policies in use in Europe and in neighbouring states, including guidelines and legislation, are included This action will be realized also through the meeting between the partners.

WP4.3 Realization of a GIS (Geographic Information System) and data normalization

the GIS will be realized through the acquisition of the digitized cartography, the classification and organization of such cartography identification of the optimal software tools and set of GIS application to be linked to the db's development at action 4.4

WP4.4 Decision Support System development

The DSS will provide the authorities of the involved territories with a tool for the strategic planning of the algal bloom management and in the future to remove the main causes (wastewater treatment, nutrient discharge, pollution, etc). Objective of this task is the development of a DSS for systemic management on the basis of the GIS and database systems (developed in the actions 4.3, 4.4 and 4.5). Using a DSS, different possible scenarios of future development and trends can be simulated to identify an optimal methodology approach (pollution prevention and control, water treatment and distribution, cost recovery, etc).

Deliverables (brief description and month of delivery)

A guidelines on data collection and management (heading to the harmonization and utilizable beyond the scope of the project (M3)

A social mapping of the relevant stakeholders and the role (M8)

Database structure built up (M8)

Database filled up with data collected integrated with relevant data at basin level and linkage with other db (M24)

DSS design and development (24M)

WP5 Project management (WP coordinator: ENEA; PPs involved: UU, NIVA, UNIVPM)

This WP encompasses not only "classic" project management but also coordination of the work and dissemination of results.

Reporting: the most important element of the project management is the effective communications and the project management team will be dedicated to ensuring that all project participants are sharing information as fully and efficiently possible. The SC will meet at least quarterly and will make sure that each participant is fully apprised of the project progress. The Sc will work together continuously and will schedule meetings (mainly via Skype) with individual work package managers according to the stage of the project and the live work packages.

Quality management: the importance of an effective quality assurance scheme will most evident in delivery of making and testing work packages. However the quality must be determined during the design stage (i.e. standards and guidelines for analytical methods or toxins characterization). Developed and adopted best practices will be adhered to requirement fro certification, material sampling, etc.

Document management: the SC will establish a document management system based around a secure intranet and agreed naming system which allow relevant parties to store, access and communicate up to date documents, data and records throughout the project. The document management system will be central to minimizing the administrative risks due to the complexity of the project.

Budget management: the project budget will be periodically checked and updated by each partner.

1.5. Originality and innovative aspects of the research (ambition)

The research and development performed in the BLOOWATER project is expected to make a new "systemic approach" allowing the best practice in order to solve a serious problem which, according to the forecasts, will in future be more and more widespread putting at risk the human health. The originality and innovative aspects mainly consist of:

- Development of a local monitoring network, which through the historical series and the acquisition of the main parameters supports the local Water supply system. In particular the constant monitoring system allows to alert the water control laboratory that will be able to verify the toxicity of algal bloom in the field. This will allow to warn the stakeholders about the actions to be taken, locally, moreover the connection with the drinking water treatment plant through the plant's PLC will allow the activation of the drinking water treatment. The shortness of the following phases: monitoring, warning and start-up of the treatment plant will be ensured by the network set up by the proposed project;
- Using commercial systems/items such as Cyanotox, multi-parameter sensors, drones and software, contributes to reduce the network management costs and to optimize the performances of drinking water treatment plants;
- The polymer enhanced filtration can be a novel alternative to treat waters polluted by cyanobacteria. Natural polymers can be used to modify the physic-chemical properties of pollutant in order to increase ist rejection performances reducing both, the equipment complexity and treatment costs.
- The cyanobacteria toxicity will be reduce by using sustainable treatment solutions and optimizing the operative costs (eco-friendly coagulant, fouling UF minimization, pulsed UV).
- Novel process solutions and optimal configuration will be tested to enhance the quality of the drinking water production from surface water. The long term operation, the TRL and the performances and economic assessment with the conventional technologies will assure the validation of the final results.
- Finally a DSS will describe different possible scenarios of future trend in order to optimize the problem management and in particular the water treatment system.

1.6. Clarity and quality of transfer of knowledge for the development of the consortium partners in light of the proposal objectives

BLOOWATER partnership comprise of HAB researchers with diverse expertise spanning the HAB species eco-physiology and their implication for ecosystem health, water monitoring, observational platforms, time series analysis, prediction and treatment solution. Partners will benefit from this specific expertise to enhance the project efficacy and impact. Previous research experiences can serve as bases for assessing of current knowledge and key gaps in HAB science. The automation of HAB sensing is a new environmental challenging and trend detection of HAB in freshwater systems need be greatly assisted by development of simplified tools. The consortium partners will greatly accelerate the critical data acquisition testing the new tools and integrated approach: monitoring, modelling and treatment. Furthermore geographical distribution of BLOOWATER partners will allow transferring models and forecasting platforms from one region to another with appropriate guidance improving to knowledge of HAB geospatial distribution. The participation of different countries sharing problems with relation to the environment seeking common and novel solutions for the benefit of everybody represents and added value to the approach, BLOOWATER takes into account the rights of the natural environment for the benefit of the future generations. Dissemination, demonstration of methods proposed and knowledge transfer are highly relevant for the project and will be realized via reports, articles and workshops all along the life-time of the project.

1.7. Quality of the consortium partners and collaborative arrangements. Capacity of the consortium to reinforce a position of leadership in the proposed research field

The project team consists of established leading researchers and early career researchers. All the partners of BLOOWATER have a strong expertise in EU projects, being involved, as coordinator or participant, in several EU projects (Water JPI, JPI ERA-NET, COST actions, Eureka, FP7 and H2020) related to the research objectives of the project.
Therefore in BLOOWATER we will test some of the models presently developing in PROGNOS and ISIMIP and use also Lake Erken as a test site for the BLOOWATER monitoring system and model forecasts.
In addition to experience gained with following projects:

INTCATCH - Development and application of Novel, Integrated Tools for monitoring and managing Catchments
The project aims to develop an innovative approach towards monitoring and managing water bodies providing decision support systems for water monitoring. The role of UNIVPM is cantered to the design, management and performances evaluation of demonstrative pilot unit.
HYDROUSA - Demonstration of water loops with innovative regenerative business models for the Mediterranean region. The project will provide innovative, regenerative and circular solutions for nature-based water management of Mediterranean coastal areas, closing water loops; nutrient management, boosting the agricultural and energy profile; and local economies, based on circular value chains. The role of UNIVPM is centred to the validation the transferability and replication in different sites of the Hydrousa technologies.
The project coordinator has long-standing and renowned experience (see details in CV).
Examples of the scientific expertise and management capacity of the coordination group in the proposed field are ongoing and recently completed projects on the topics relevant to the BLOOWATER: JPI Water PROGNOS, JPI Climate WATExR, NordForsk DOMQUA.
None of the groups possesses the expertise, instrumentation, know-how and critical mass for developing this multidisciplinary project individually. Therefore, the objectives are only achievable with the input of all partners.
The partners clearly demonstrate their expertise through the publications and patents, published and registered in these years (see chapter 5. CAPACITY OF THE CONSORTIUM ORGANISATIONS)

Exploitation Strategy
All the basic principles of knowledge and access rights as well as the rules for protecting the project results will be clearly agreed upon in the Consortium Agreement.

2. IMPACT

2.1. Impact of the proposal

(A) The project addresses SDG 6 through contribution to understanding and reducing pollution related to toxins from algal blooms and increased safe drinking water (6.1) and through implementation of integrated water resources management (6.5)
The project addresses SDG 13 by developing early warning systems towards better adaptation and impact reduction of climate changes (13.3) and by developing effective treatment solutions to strengthen resilience and adaptive capacity to climate-related hazards (13.1).
(B) Considering impact not mentioned in the Call Announcement, the BLOOWATER produce an approach model for creation of information resources for Public water supply systems and Agencies to prepare and respond to the risk of the cyanotoxins in drinking water. Moreover the comparison of the treatment processes (and equipment) developed mainly at lab scale, will improve the knowledge regarding the cyanotoxins issues managing.

(ii) The project will contribute to describe suggestions for managing cyanotoxins issues in raw and finished water. Moreover the project will provide examples of how Public and private utilities can manage this risk. The main barrier/obstacles can be attributed to the inadequate regulations at local level and in particular regarding the management of the single water system supply in the Mediterranean region.
Often Public Water Supply Systems don't consider how likely their systems may be to encounter cyanoHAB's in their source water and how they could benefit from adopt a system specific cyanotoxins management plan prior to the bloom event. A strong action towards the main actors is necessary to convince them to apply innovative systems for monitoring and controlling the plants and the water distribution network.
Another obstacle could be represented by the general lack of knowledge concerning the hazards arising from cyanotoxins. Considering that algal bloom is a seasonal phenomenon and therefore destined to run out in a few days, people tend to underestimate the phenomenon and above all the related consequences.

2.2. Expected outputs

The key goal of the partners is to contribute to the development of a new approach regarding a great problem that afflicts many reserves of water destined for human consumption. In particular a new generation of monitoring systems correlated to an innovative treatment process that is more effective at complete removal, more cost efficient and, last but not least, more sustainable.
Planning technical, legal and institutional national instruments to determination, remediation and improvement of water quality across the countries. Improvement of national (and international) coordination and in particular to start a National project on the control of pollution (and risks) caused by cyanotoxins.
A guidebook on basic principles and norms related with monitoring, design and planning and integrated systems to reduce the risks due to cyanobacteria.
Videos and literature containing case studies for stakeholders, technicians, students and citizen interaction.
Development of new partnerships with SME.
The selection of an appropriate methodology is a key decision in any multi-operative modelling problem therefore an important expected output of the BLOOWATER project is a specific base model to allow further analysis of the data to support future projects.
Naturally software applications, publications, communications in meetings and reports are expected output including the pilot plant and patents (in this case specific agreements between the partners will be agreed).

Expected Output	BLOOWATER impact
Increased customer satisfaction with drinking water services	New methods for improved drinking water quality production
Implementing accessible solutions for clean water management and climate resilience to address UN SDG6 and SDG13 targets and associated SDGs	The technologies, tools and strategies developed during the project will contribute to spread of safely managed drinking water services for all (SDG6), improved integrated water management (SDG6) and strengthen resilience to climate related-hazards like algal blooms (SDG13). The project will also impact on SDG1, SDG3, SDG9, SDG17 (social benefits).
Knowledge on strategies for algal bloom impacted water	Innovation and development of tailored monitoring and predictions tools, and treatment solutions for algal bloom waters

2.3. Exploitation and communication activities (measures to maximise impact)

A planned process of providing information on the results of the project programmes to key actors will be developed. In particular the BLOOWATER project Dissemination, Exploitation and Communication Strategy (DECS) and its implementation plan to be used by the consortium to ensure the high visibility, accessibility and promotion of the project and its results during the grant period will be performed and it occurs as and when the result of programmes and initiatives become available. This DECS will be a reference framework for evaluating the impact of communication and dissemination activities and will be updated and adjusted as the project progresses. In particular the communication and dissemination actions provides: Notice boards creation, official website, a Layman's report (targeted at non specialist audience), involvement of stakeholders through local workshop. Moreover during the project the main actors of the water supply services will be involved in the activity plan (i.e. in Italy the associations of the mayors, ANCI, and of the service companies that manage the water network, UTILITITALIA) in order to transfer the results and the knowledge.

2.4. Market knowledge and economic advantages/return of investment

Milion of people around the world need and depend upon freshwater or marine water for obtaining resources and services depending from the waterbodies protection. Cyanobacteria have caused severe consequences to both animal and human health. The elimination of cyanobacterial toxins is complex (WHO & European Commission, 2002). Water treatment should not be an option until other techniques, such as selection of intake depth and use of barriers to restrict scum movement, have been used (Haider et al, 2003). Water treatment must be the solution to safe the human health. When discussing the adverse effects from cyanobacterial toxins includes mainly three areas of impact; tourism/recreation, livestock/fisheries and drinking water. An exaustive report on the economic impact of algal bloom has been recently published (EUR 27905) according to this report the impact on these areas can be evaluated in many billions of dollars per year.

Considering the supply of drinking water only, the damage can be enormous and a good example can be what happened in 2014 in Toledo (Ohio, US). The best option when faced with eutrophication in a drinking water reservoir is to depend on secondary source for water production. Bottled drinking water may be an optionbut it is not certainly sustainable in terms of environment and costs. The benefits of reducing cyanobacterial blooms are the reduction in damages and adverse effects, the benefits can be valued by the costs that may be avoided. About 20 years ago the overall costs in Australia related to cyanobacteria were estimated in 180-240 millions$ per year (Atech 2000 Atech (2000) Cost of algal blooms. Report to Land and Water Resources Re- search and Development Corporation, Canberra, ACT 2601 ISBN 0 642 76014 4).Information to the affected parties is vital (cyanobacterial blooms can be highly unpredictable) the costs involved in assessing the nature and extent of the bloom will depend on its size and the facilities available for testing the toxins. Toxicity tests may cost over $1,000/sample. Therefore blooms in small isolated storages may be relatively easily monitored and cost a few thousand dollars per annum while blooms in large water bodies that connect with other water bodies may cost hundreds of thousands to adequately assess.

Prevention of future problems can involve dealing with the factors that cause blooms (long term activity) or improving the treatment of the water once the bloom occurs (short term activity). Considering that the phenomenon is in continuous expansion and that in Italy there are no specific treatment plants, the potential market is broad and is mainly associated with the engineering companies (design and construction), service companies (management and monitoring), private laboratories (analytical control) and finally to central authorities (control and monitoring). Following the end of the BLOOWATER project, the applications of the results we expect a strong interest from companies who already include these sectors in their activities.

Project management is often isolated from business decision making related to the project, typically decision-making concerns not just with cost and time but with payback periods and return of investment. Considering that BLOOWATER mainly is a research activity related to a dramatic and growing problem such as the human health, a novel “multiple barrier approach” utilizing new technologies should have a great and immediate economic advantages and, therefore, return of investment. Partnership with SME are expected to facilitate the return of investment because with high-technology products such as BLOOWATER deliverables, the first company to market the solution developed by the project can charge high price for a time sufficient to return the investments. For the research partners there is not only economic return, in fact the experience and expertise gained in this project is planned to be used to develop new processes and analytic methods fro additional activity in the frame of the water treatment (i.e. wastewater treatment in the industries as circular economy approach). In other words partners (research centres and university) can become a national reference for all the actors involved in this sector. Contacts have already started with SMEs that are currently involved in the services sector in the Lazio Region (Bolsena Lake)

3. IMPLEMENTATION

3.1. Overall coherence and effectiveness of the work plan

WP Nr	WP Title	Duration (months)	Starting Month	End Month	WP Description
WP1	Monitoring system development	26	2	33	Development of monitoring strategy based on a tiered approach, combining remote and proximal sensing technology with in situ aquatic monitoring
WP2	development of bloom forecasts warning system	33	2	34	To produce forecasts of the probability of increases in cyanobacteria biomass.
WP3	Treatment process comparison	35	1	335	Study, develop and validate sustainable and efficient technologies for the treatment of water affected by cyanobacteria toxicity
WP4	DSS development	35	2	36	The DSS will provide the authorities of the involved territories with a tool for the strategic planning of the algal bloom management and in the future to remove the main causes (wastewater treatment, nutrient discharge, pollution, etc)
WP5	Project management	13	1	36	coordination of the work and dissemination of results. Reporting, quality and document management

3.2. Appropriateness of the management structure and procedures, including quality management

The project will be led by ENEA which will take responsibility through the project management work package (WP5) for effective coordination of the contributing consortium members. ENEA will be committing its most experienced members of staff to the delivery of this high profile project. Each partner in the consortium will provide dedicated work package managers to make up the Steering Committee (SC) and facilitate clear and effective communication throughout the consortium. The SC will convene at least once a quarter to review project progress, and will meet with the project officials as required and/or requested. The SC including the Project Manager will be responsible for review and approval of completed milestone before their submission.
Decision hierarchy: the consortium will agree a set of thresholds based on risk, schedule impact and/or budget impact which will be adhered to when determining the appropriate decision making authority from the individual work package manager to the Project Manager. The hierarchy reflect the management structure and the PM holds the ultimate decision making authority in the event that the SC fails to reach a majority verdict. Member of consortium unaffected by decision may act as arbiters in the contentious making processes.

3.3. Risk management

Managing risks on the BLOOWATER project includes risk assessment (identification and evaluation) and mitigation strategy (elimination or minimization the impact) for those risks. The management process includes meetings with all partners where the team will create a list of everything that could go wrong. In particular: Identification of the major elements in managing the project risk; description of the identification, evaluation and mitigation tools to manage the problems. A risk breakdown structure will be developed in order to easily evaluate the removal/mitigation actions.
Potential sources of risk can be:
Technical (inadequate separation technique, difficulty in managing the tests with the pilot plant, difficult in supplying sufficient natural polymers,);
Costs (unexpected cost relating equipment and or ICT);
Environmental (difficult to manage the waste coming from the processes);
People (difficulty in talking to citizens, stakeholder etc);
Contractual (detailed definition of roles in the contract phase with SMEs and/or public administrations);
Weather (logistical difficulties for sampling).

3.4. Potential and commitment of the consortium to realise the project

The structure and size of the project consortium and the proposed project activities have been formulated to ensure a cost effective approach to realising the project objectives. Care has been taken that all activities are well covered, and the amounts are realistically presented.
BLOOWATER has 4 academic/research partners having a strong and well distributed knowledge, all partners have allocated resources as well as a substantial financial (and human) support to contribute over the entire project. The purpose of the BLOOWATER is to develop and implement sustainable and easily manage the initiatives that strongly reduce the risk derived from cyanotoxins. Each partner has experience and knowledge to successfully realise the project. In addition, the partners have a strong interest in developing skills that can implement relations with SMEs in their territory. The institutions are directly involved since every year there is an emergency that denies water to thousands of citizens (in particular the institutions are directly involved since every year there is an emergency that denies water to thousands of citizens (especially in countries that draw drinking water from the lakes of Bolsena and Vico or those countries that suffer economic damage to due to both the lack of tourists or for the consequences deriving from the death of fish).

GANTT CHART (R=Report, FR=Final Report).

Month/ Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
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4. DESCRIPTION OF THE PARTICIPATING RESEARCHERS

Partner Number, according to Part A	Research Team Members (for personnel include name, position and affiliation)	General Description
Uppsala University, Sweden Don Pierson (PI)	Don Pierson Senior Research Scientist Dept. of Limnology.	Presently coordinator of Water JPI PROGNOS project and co-coordinator of the ISIMIP (www.isimip.org) lake sector. Previously led evaluation of the effects of climate change on New York City water supply. Models used in these projects will be further developed for BlOOWATER
	PhD student to determined	Will assist in model development for predictions of algal blooms and cyanobacteria
	Researcher 3 Name, Position, Affiliation	
Partner: Polytechnic University of Marche (Principal Investigator: **Francesco Fatone)** **Partner: Polytechnic University of Marche** (Principal Investigator: **Francesco Fatone)**	**Anna Laura Eusebi** **Researcher, Polytechnic University of Marche**	Assistant professor of Chemical-Environmental Engineering. Her main research topic is related to the advanced biological and chemical processes for removal and recovery the main nutrients. Her expertise is mainly applied in demonstration and full scale plants with collaborations or coordination of about 40 applied research commissioned by water utilities, water industries and public authorities. Anna participated in two European projects (FP7) and is currently involved as key researcher in 4 H2020 projects (SMART-Plant, ENERWATER, INTCATCH, HYDROUSA)
	Stefania Gorbi, **Associate Professor, Polytechnic University of Marche**	Associate professor of Applied Biology at the Polytechnic University of the Marche, Department of Life and Environmental Sciences. Her main research activities concern the use of aquatic organisms as bioindicators of environmental quality with particular attention on the effects of emerging contaminants including drugs, bioactive molecules of natural origin (biotoxins and algal metabolites) and microplastics, development and use of application software for environmental risk analysis. Project research manager in projects such as JPI OCEANS EPHEMARE; PRIN 2009 CAUDIP project; PRIN 2012 CAULERFISH project.
Partner 3: ENEA (Principal investigator Loris Pietrelli)	**Loris Pietrelli Senior Research Scientist**	Design, construction of drinking water treatment plants and wastewater treatment for small communities. From 2012 contract professor at La Sapienza University (Rome) of "Sustainable using of polymer materials"
	Maria Sighicelli Research scientist	Freshwater ecologist expert with experience in environment monitoring, eco physiology, and analysis of phytoplankton and cyanobacteria in particular.
Partner 4 NIVA Christian Vogelsang	Dr. Eng. Pawel Krzeminski, Research Scientist, NIVA	Environmental engineer, expertise in membrane processes, fouling mitigation methods, drinking water treatment, and removal of emerging contaminants. Projects: LCMTC on development of long channel membrane test rig for membrane fouling studies; DOMQUA and CLIMER dealing with drinking water and climate responses
	Dr. Andreas Ballot, Senior Scientist, NIVA	Freshwater ecologist expert with more than 17 years' experience with the ecology, phylogeny and toxicology and cultivation of cyanobacteria.

5. CAPACITY OF THE CONSORTIUM ORGANISATIONS

Partner Nr(Organisation Name)		General Description
Uppsala University Don Pierson (PI)	**Role and main responsibilities in the project**	Uppsala University has extensive experience in lake modeling including future climate simulations The Dpt of Limnology, has a long established research program focusing entirely on limnology.
	Key research facilities, infrastructure, equipment	The Lake Erken field station has a long record of limnological research, including an established lake monitoring program. The lake normally experiences a mid-late summer cyanobacteria bloom (*Anabena sp. and Gleothricia echinulata*) Since 1989, high frequency lake meteorology and water temperature data have been collected, and these long-term high frequency data and monitoring systems will be a key resource to this project. Some of the models that are proposed for this project have already be tested and applied on Lake Erken. Future simulations of Erken water temperature have already been contributed to the ISIMIP.
	Relevant publications and/or research/innovation products	Matonse, et al. 2012. Primary Water Supply. Climatic Change 113. DOI 10.1007/s10584-012-0515-4. Marcé, R., et al 2016.. Environmental Science & Technology. Brentrup, J. A., ., et al 2016. Inland Waters 6:565-580
Partner UNIVPM	**Role and main responsibilities in the project**	UNIVPM will be mainly involved in the definition and testing of specific technological treatment solutions for cyanobacteria reduction (WP3).
	Key research facilities, infrastructure, equipment	UNIVPM can count on: a 200 m2-large pilot/demo hall located in the municipal WWTP of Falconara M. ma (AN), where tertiary pilot units (ozone system; UV lamp; membrane pilots) are available and validated in real environment (http://www.simau.univpm.it/node/185). The pilot hall is associated to a Res. Lab. of Chemical and Environmental Engineering (UNIVPM). Ecotoxicology and Environmental Chemistry Labs at Life and Env. Sci. Dept. fully equipped for laboratory exposures with marine organisms, chemical analyses of all classes of environmental pollutants and ecotoxicological analyses.
	Relevant publications and/or research/innovation products	European Projects on Water/Wastewater Topics: HYDROUSA H2020 project - "Demonstration of water loops with innovative regenerative business models for the Mediterranean region Project id: 776643) ROLE: F. Fatone WP leader. NTCATCH H2020 project - Development and application of Novel, Integrated Tools for monitoring and managing Catchments (Project id: 689341) ROLE: F. Fatone WP leader www.intcatch.eu . jpi oceans ephemare. Ecotoxicological effects of microplastics http://jpioceans.eu/ephemare. Bolzonella Det al., J. Env.Mang. , 91 (2010) 2424-2431. Cingolani et al. Waste Management 76 (2018)566-574. Wang et al. J. Membrane Sci. 555(2018) 125-133
Partner 3 ENEA	**Role and main responsibilities in the project**	ENEAwill be mainly involved in the development of monitoring system (WP1) and will be the main coordinator of the project (WP5).
	Key research facilities, infrastructure, equipment	ENEA has highly qualified personnel, advanced laboratories and facilities (labs and pilot plants) useful for the realization of the projects.The activities are dislocated in 9 res. Centres throughout the country (www.enea.it).
	Relevant publications and/or research/innovation products	Pietrelli et al.Chem. Eng. Journal341(2018)539-546. Innocenzi et al J. Clean. Prod. 172(2018)2840-52. Pietrelli et al. Carbohyd. Polymers 179(20189273-81. Pietrelli et al Chem. Eng. Tra. 70(2018)271-276. Pietrelli et al Polymer Bull 74(2017)1175-91. Sighicelli et al Env. Pollution 236(2018)645-51. Pietrelli et al Env. Poll. Res 24(2017)16536-42
Partner 4 NIVA	**Role and main responsibilities in the project**	Review of technologies for treatment of algal bloom impacted waters, lab-scale NF tests, membrane biofouling mitigation, impact of algal toxins on water quality (WP3)
	Key research facilities, infrastructure, equipment	Dedicated membrane laboratory with lab- and bench-scale membrane systems for flat sheet, hollow fibre and spiral wound membranes evaluation, including test rig for full length membrane biofouling studies. In-house ISO and GLP certified chemical, biological and toxicity laboratory offering full range of chemical analyses and toxicity determination. The Norwegian Culture Collection of Algae, NORCCA, maintained and owned by the NIVA and the University of Oslo (UiO), includes more than 700 cyanobacterial strains. It hosts a variety of cyanobacterial species producing different kinds of cyanobacterial toxins.Large-scale research station in Solbergstrand for testing of water treatment systems.
	Relevant publications and/or research/innovation products	Ballot, A; Scherer, P; Wood, S. 2018 Variability in the anatoxin gene clusters of Cuspidothrix issatschenkoi from Germany, New Zealand, China and Japan. PLoS ONE 13 (7) e0200774Ballot, A., Cerasino, L., Hostyeva, V., Cirés, S., 2016. Variability in the sxt Gene Clusters of PSP Toxin Producing Aphanizomenon gracile Strains