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smat
CENTRO RICERCHE

Research activities

FEBRUARY 2018

smat
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Research activities

FEBBRUARY 2018

BS OHSAS 18001:2007
CERTIFICATO N. 9192.MACT

UNI EN ISO 1400:2015
CERTIFICATO N. 9191.SMTO

UNI EN ISO 9001:2008
SGQ Certificato n° 343

SMAT Research Center: a reward for the commitment to research and innovation

In 2017 the SMAT Research Center celebrated its ninth year of activity. During these years SMAT has devoted a significant part of its structure and resources to Research and Innovation, by participating to prestigious National and International projects and by attracting to its Research Center new talents and qualified collaborations.

These are the motivations behind SMAT assignment of the TOP UTILITY RESEARCH & INNOVATION award, received during the presentation of the study "Performances of Italian utilities. Analysis of the 100 main companies that operate in the energy, water, gas and waste sectors" carried out by RSE Ricerca and Althesys Strategic Consultants.

Top Utility Award Ceremony, Milan, February 22, 2018. From left to right: Camilla Burdizzo, Ornella Celi, Francesca Bersani, Lorenza Meucci, Paolo Romano, Alessandro Marangoni, Elisa Brussolo, Beatrice Coloru, Marco Scibetta, Gerardo Scibilia and Sara Steffenino.

After a vibrant competition with ENEL Research, IREN, HERA and CAP Group, SMAT turned out as the best utility and was awarded by Alessandro Marangoni, Althesys CEO, on February 22 at the Chamber of Commerce of Milan.

Constant and continuous activity and commitment to applied research and innovation demonstrated their effectiveness at the SMAT Research Center: a place where applied research aggregates Italian academic and industrial excellences.

This is an important input for the new year, marking the tenth anniversary of the SMAT Research Center.

Research Center Director
Lorenza Meucci

President
Paolo Romano

February 2018

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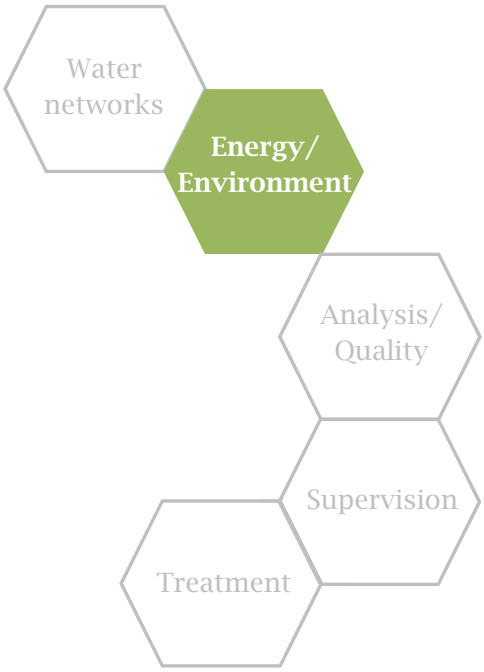
ENERGY BALANCE OF CASTIGLIONE TORINESE SEWAGE PLANT



The project focused on the biological oxidation section of the four water treatment modules of Castiglione Torinese sewage plant, the biggest Italian sewage plant, in use for more than 30 years, evaluating energy consumption, plant efficiency, process management and identifying critical points.

First, a benchmarking analysis was carried out to understand "where" the plant is positioned in terms of energy consumption characteristics. During the first phase of the project, the operating parameters of activated sludge basins were analyzed. Statistical and time series analysis were performed, considering supplied and required air and highlighting the desirable improvements.

Four different consumption indexes were evaluated and compared in the benchmarking analysis: kWh/m3 of treated water, kWh/PE (Population Equivalent), kWh/kgCODrim, kWh/kgNrim.
Results showed that SMAT sewage plant falls within the average literature values and has good performances compared to other national and international sewage plants. The analytical evaluation of the real amount of air supplied in the biological oxidation basins, thanks to data collection campaigns carried out in 2016 and 2017 (both in summer and in winter), showed that the plant, despite very good performances in terms of removal efficiency, could be improved in terms of energy efficiency. This is due to worn components such as turbochargers, compressed air production systems and oxygen transfer systems.
The upgrading program for changing these components has already started.

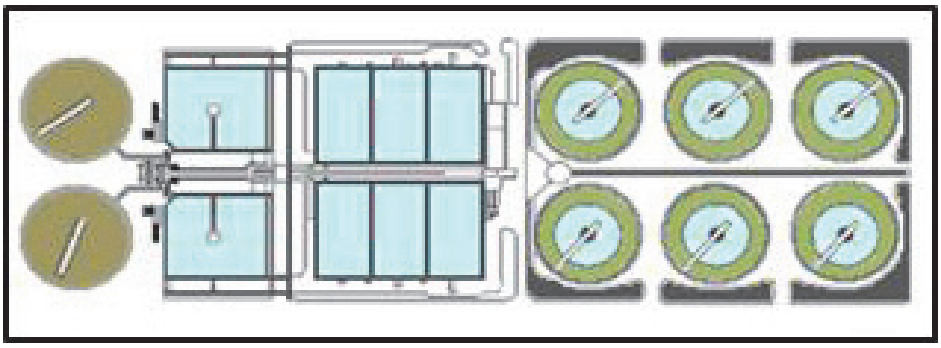
STATUS
Closed

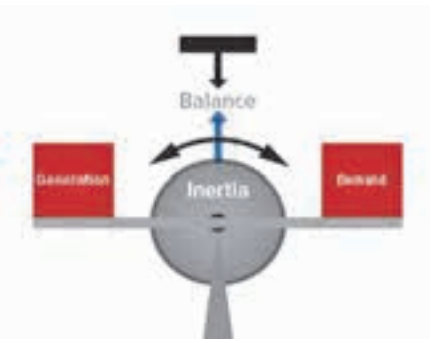
STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

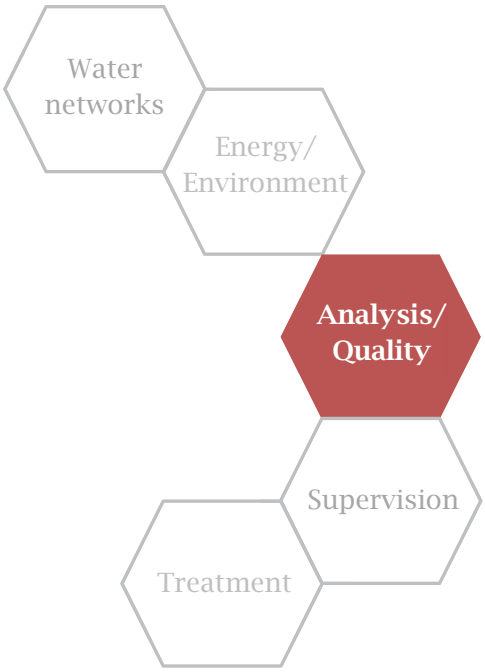
PARTNERS
Polytechnic University of Turin





"Benchmarking analysis and data collection campaigns on Castiglione Torinese sewage plant showed good performances of the plant and allowed to focus on specific interventions on activated sludge basins to optimize energy efficiency"

DATA MANAGEMENT FROM ON-LINE ANALYZERS AND LABORATORY MANAGEMENT SOFTWARE



The project was articulated on two major technological solutions:

- Mobile devices to digitalize sampling activities, to optimize the flow of information throughout sample reception and laboratory analysis and to improve the process in terms of security and data traceability;

- The use of online analyzers for specific parameters where timely analytical data management is more highly desirable.

During the last year of work, operative procedures to use online analyzers for management purposes were established and tested: aluminum and algae were the selected parameters.
Partners completed the pilot tests, shared and compared the results for future reporting use.

Based on the positive outcome of the aluminum trial (data validation, establishment of internal procedures, comparison with traditional ICP-MS analysis), a new project has been launched by the same Hera-Iren-Smat working group. Specifically, the goal of the future project will be data validation of online measures considering accreditation criteria such as global procedures, interlaboratory tests and sharing of experiences.

STATUS
Closed

STARTING DATE
December 2014

DURATION
36 months

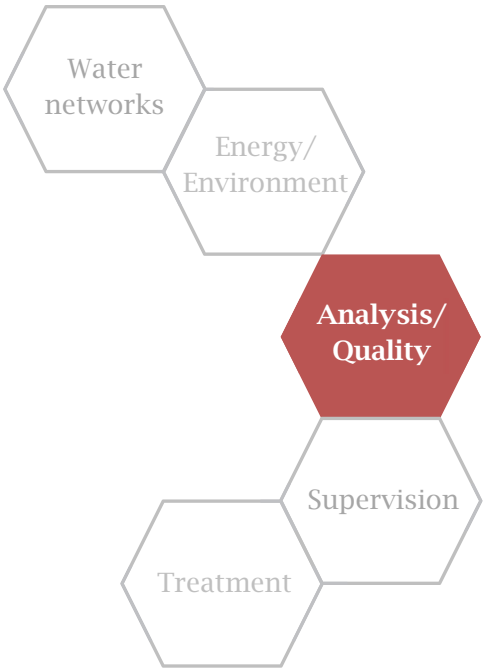
FUNDING
No

PARTNERS
Hera, Iren

"This approach will allow a better and earlier management of anomalies and it will make the analytical system more efficient in terms of expertise, resources and timing"

Cod: LRC_2014_09

WATER SAFETY PLANS TOOL



Introduced by the European Commission in 2015, WSPs aim to systematically guarantee hygienic safety in drinking water systems, quality of distributed water and consumers' health protection, through a comprehensive risk assessment and risk management approach that encompasses all steps in water supply.
The main structure for the implementation of WSPs is defined in a number of guidelines, developed both at the national and international level; nevertheless, the implementation of Water Safety Plans in small systems can be difficult for the lack of homogenous evaluation criteria.

In this framework, SMAT Research Center started a project with the aim of defining an operational tool for risk assessement, based on homoegeus criteria. This will provide a scientific basis for risk assessment and allow comparison of results and integration with other tools currently in use within the company. For each water supply step, risk assessment models (checklists) have been created along with the definition of a list of all possible events, probability classes, gravity leves and, at the end, possible existing control measures, together with efficiency levels. Initial and final risks are automatically calculated once the checklist has been filled in by the operator.
The Water Safety Plan tool, tested on three pilot municipalities, resulted in a homogenous evaluation, that allows to define priorities for technical intervention at the company level. This WSP tool, consisting of risk assessment checklists and a manual, was registered to SIAE for copyright protection.

STATUS
Closed

STARTING DATE
April 2016

DURATION
20 months

FUNDING
No

PARTNERS
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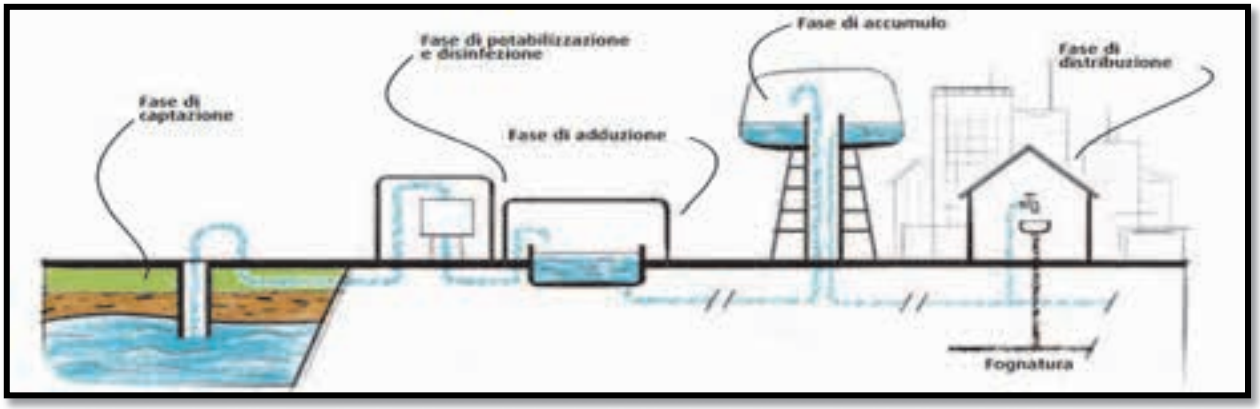
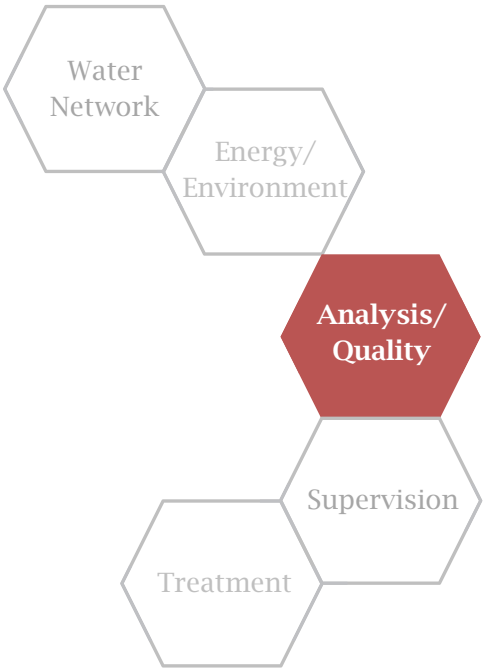


"The Water Safety Plan tool, tested on three pilot municipalities, resulted in a homogenous evaluation, that allows to define priorities for technical intervention at the company level"

Cod: LRC_AC_2016_17

IMPLEMENTATION OF THE WSP TOOL IN SMAT MUNICIPALITIES



The project "Implementation of the WSP Tool" consisted in the application of the tool, developed by SMAT Research Centre, for the implementation of different Water Safety Plans. The purpose of the project was to carry out the risk assessment on 6 municipalities that were considered "critical" according to different criteria: number of microbiological anomalies in the distribution network, low residual chlorine concentration (> 40% of the sample with a residual chlorine < 0,05 mg/l), interconnection with Torino city, large population served (> 10.000 inhabitants). Among the criteria, also the inclusion of all SMAT operational management services was considered, in order to provide a complete training to the largest possible number of staff members.

The 6 selected municipalities are representative of different size, water supply chain plant complexity, territory morphology. It was noted that the dimension of the municipality, in terms of population served, is not directly proportional to the easiness of a WSP realization, but that the main factor is plant complexity.
From the results obtained, it is possible to confirm that the tool allows to perform accurate and detailed risk assessment and to achieve results in accordance with the real situation.
No significant critical issues emerged from the risk assessments, other than some risks for which it would be advisable (not mandatory) to implement further control measures.
In this framework, action plans have been proposed for risk mitigation.

STATUS
Closed

STARTING DATE
July 2017

DURATION
6 months

FUNDING
No

PARTNERS
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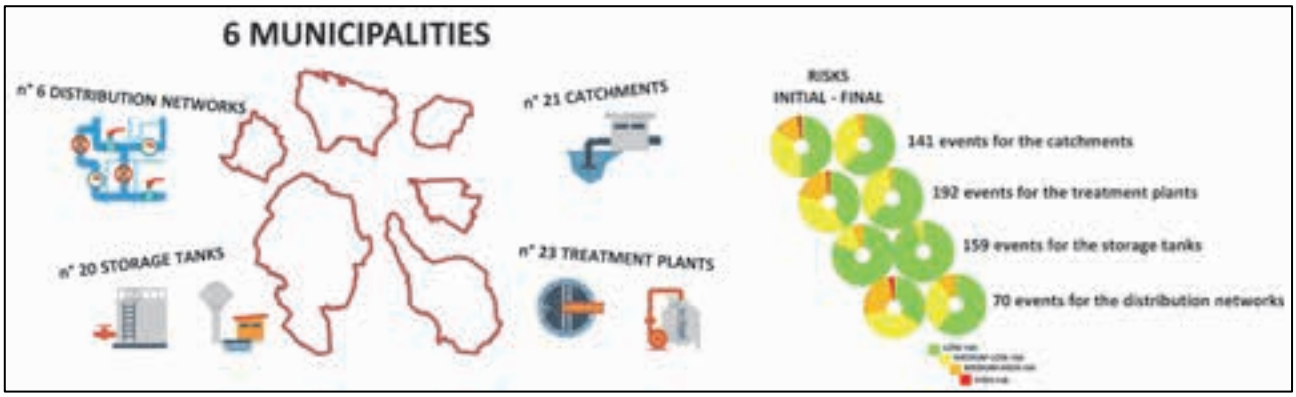
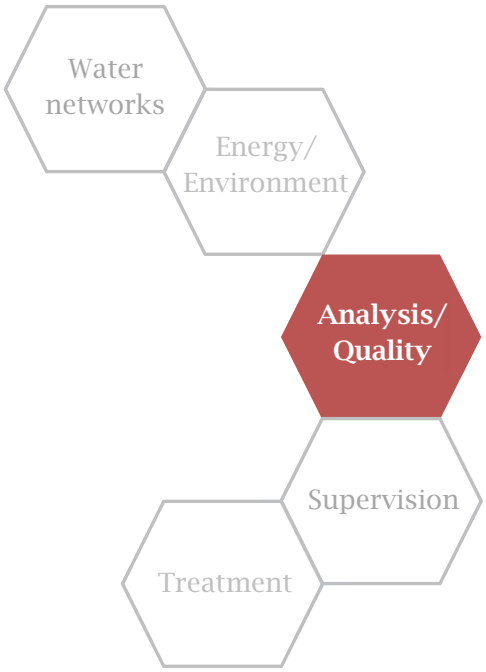


"The project consisted in the application of the tool developed by SMAT Research Centre for the implementation of Water Safety Plans on 6 SMAT municipalities".

RADIOACTIVITY IN WATER IN THE METROPOLITAN CITY OF TURIN



The presence of radioactive materials in drinking water can be harmful to human health, whether it is due to natural or artificial processes.
The recent European Directive, which regulates radiometric controls on water intended for human consumption, has been recognized in Italy by Decree of Law 28/2016. It establishes the obligation for regional authorities and utilities to implement a control program, based on preliminary assessments and probabilistic criteria.
In July 2016, SMAT started a project aimed at screening the amount of radioactive substances in water in the Metropolitan City of Turin.

The first phase of the project (July to December 2016) mainly consisted in the installation and setup of the measurement system. Relevant monitoring parameters (tritium, radon, gross alpha and gross beta activity) are measured through liquid scintillation counting. The selected latest-generation counter is able to detect very low signals, typical of environmental samples. In 2017, we measured 700 water samples, representing more than 200 municipalities with a total population of about 2 million people.
The screening revealed a substantially reassuring scenario. No tritium activity was detected, as expected in the absence of artificial sources. The rare anomalies for radon activity and indicative dose (less than 2% of the samples), are slightly above the threshold limits. Further controls and, eventually, radiation protection risk assessment activities will be planned and implemented in the next months.

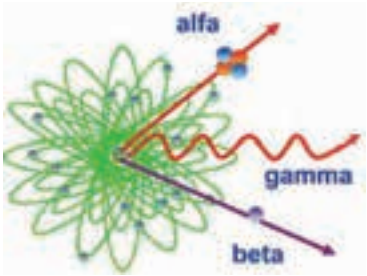
STATUS
Closed

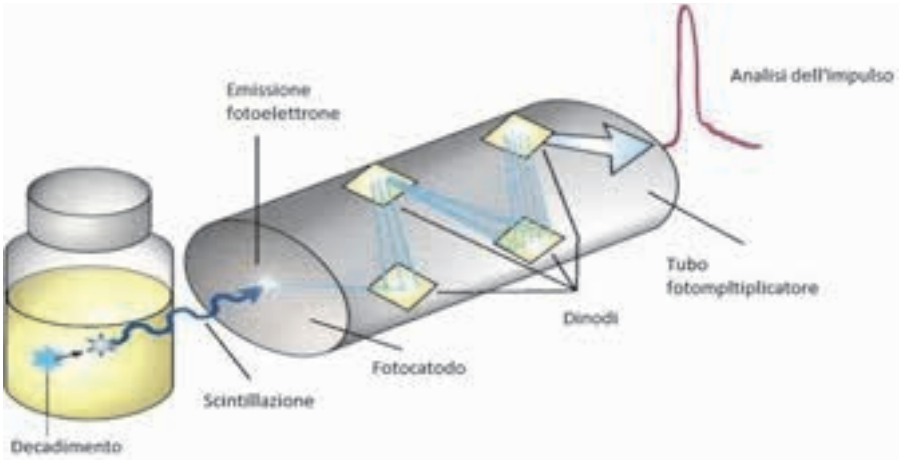
STARTING DATE
July 2016

DURATION
18 months

FUNDING
No

PARTNERS
Arpa Piemonte

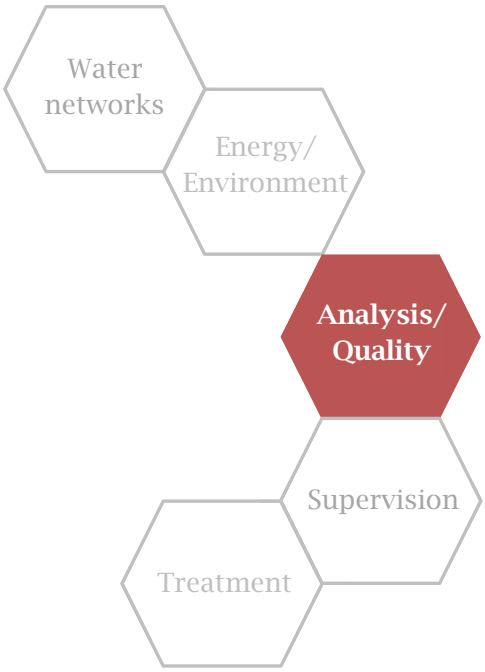




"The screening of radioactivity levels in drinking water covered a population of about 2 million people and did not reveal relevant radiation protection criticalities"

Cod: LRC_AC_2016_21

EVALUATING THE PRESENCE OF ASBESTOS FIBERS IN SMAT WATER



Asbestos is universally recognized as a human carcinogen when inhaled. No conclusive evidence on its carcinogenicity by ingestion has yet been established based on studies conducted on exposed populations served by water distribution systems containing large amounts of asbestos. For this reason, the World Health Organization has not set a maximum threshold for asbestos fibers within drinking water. Concordantly, no limits have been imposed by the European or Italian legislation. The only country where a reference limit exists is the Unites States, where USEPA (the American Environmental Agency) fixed a maximum of 7 million fibers per liter of drinking water.

Overall, SMAT water networks are only moderately affected by this problem; nevertheless, SMAT launched this project in view of surveying distributed water in the municipalities with known presence of cement-asbestos in drinking water mains and distribution pipes. Samples were analyzed by SEM technology at the Asbestos Laboratory at DIATI, Polytechnic University of Turin.

In total, 400 samples have been analyzed: in 51% of them, no asbestos was found; in the remaining 49% the value was almost always under the USEPA threshold level. This result highlights the presence of only negligible amounts of asbestos derived from water pipes, since most values were at least 2 log less than the level set by USEPA.

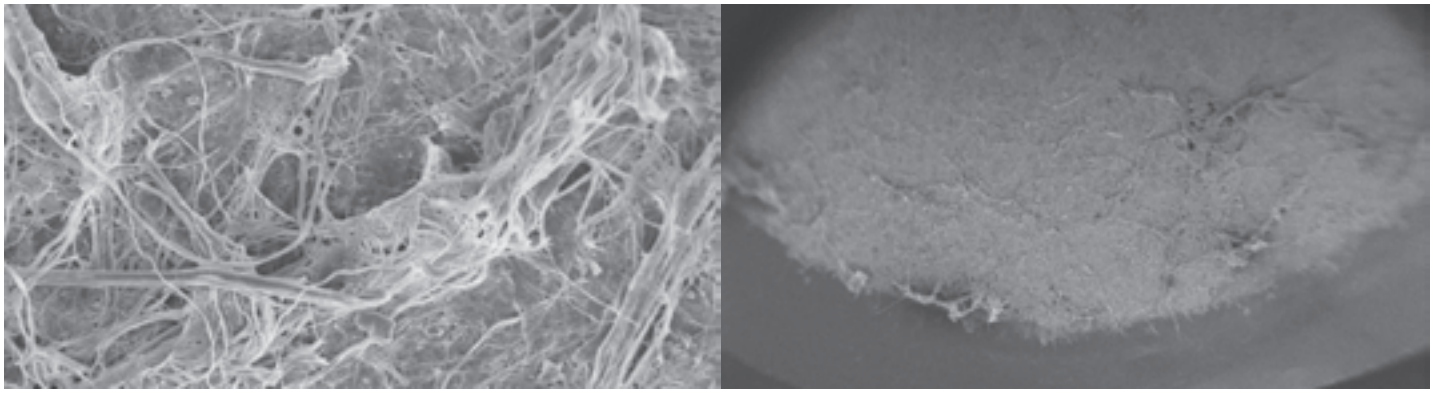
STATUS
Closed

STARTING DATE
November 2012

DURATION
60 months

FUNDING
No

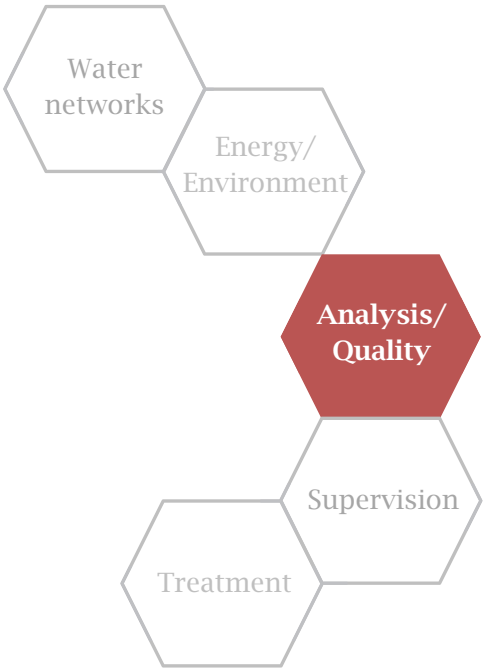
PARTNERS
Polytechnic University of Turin



"Among the 400 samples tested so far, we have not detected significant amounts of asbestos fibers derived from water pipes. Values fall below the limit set by USEPA"

Cod: LRC_AC_2012_06

EFFECT-BASED AND CHEMICAL ANALYTICAL MONITORING FOR STEROIDAL ESTROGENS



The project aims to identify and optimize a panel of methods for the detection of steroidal estrogens which can act as endocrine disruptors. In particular, analyses focused on three molecules that can alter the normal physiological functions of the endocrine and reproductive system: estrone (E1), 17β-estradiol (E2) and 17α-ethinyl estradiol (EE2). All of them have been included in the first 'watch list' promoted by the European Directive 2008/105/CE, which encompasses ten substances that represent a potential hazard for human health and for the environment, but for which data are still insufficient in order to set appropriate safety limits.

Water samples from all over Europe were analyzed using five innovative 'effect-based' techniques, able not just to determine the presence of a substance, but to reveal its possible biological effect even at extremely low concentrations independently from the identification of the specific compound causing the effect, thanks to biotechnological sensors. These analyses were able to define, with a higher degree of specificity and sensitivity than the chemical determination performed in parallel, a clear picture of the quality status of the Po river at three sampling points, from upstream of the city of Turin to downstream of the waste water treatment plant in Castiglione Torinese. A risk quotient, derived from the ratio between the presence of endocrine disruptors and the warning limit suggested by the European Union, was established for each sample. All of our samples were characterized by values far below this threshold, suggesting a negligible risk for the local population and the environment and ranking among the first four among rivers and lakes across Europe. Also the direct analysis of the effluent from the waste water treatment plant in Castiglione Torinese provided encouraging data, showing excellent performances and placing our plant third among the seventeen analyzed.

STATUS
Closed

STARTING DATE
April 2015

DURATION
24 months

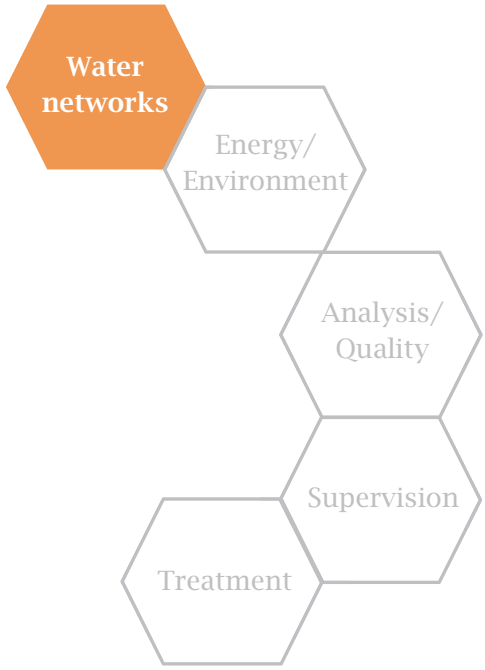
FUNDING
No

PARTNERS
Swiss Center for Applied Ecotoxicology, JRC, BDS, CNR and others

"These analyses were able to define a clear picture of the quality status of the Po river at three sampling points and of the effluent from the waste water treatment plant in Castiglione Torinese"

Cod: LRC_2015_02

AN INNOVATIVE AND INTEGRATED APPROACH FOR WATER LOSS MANAGEMENT



The management and reduction of water losses along the distribution networks represents one of the greatest challenges that water industries must face in the years to come. Due to its complexity and wideness, we decided to address this problem through a set of lines of applied research, each of which aims at testing an approach with real data. The objective is to implement an efficient and innovative methodology.

The first application implied the consolidation of a methodology for the analysis of water distribution systems, the identification of district boundaries in the distribution network and the use of data from flow meters which employ SCADA as a data collection system. The most innovative aspect of this approach will be the generation of a platform for the analysis and visualization of the distribution network status, with the ability to interconnect all the already existing pieces of information.

Another line of research aimed at the implementation of algorithms derived from a field of network science called "Community Detection". The objective of Community Detection is to detect communities inside complex networks. The purpose of this application was to support the water distribution manager in the choice of district boundaries, with an easy-to-use tool that automatically suggests how to subdivide the network.

STATUS
Closed

STARTING DATE
September 2016

DURATION
24 months

FUNDING
No

PARTNERS
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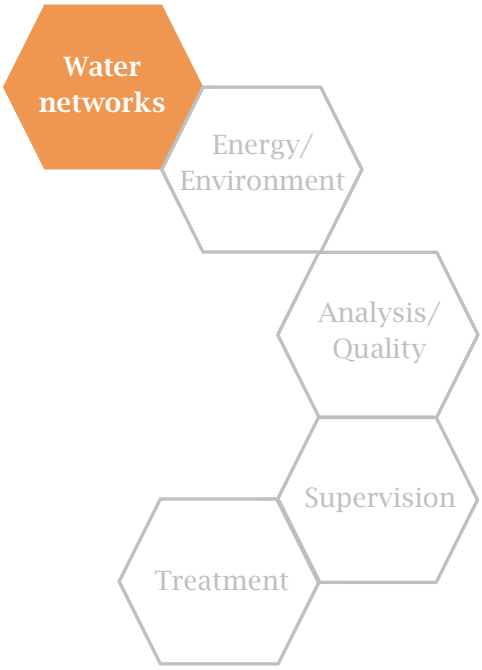
"The management and reduction of water losses along the distribution networks represents one of the greatest challenges that water industries must face in the years to come"

Cod: LRC_AC_2016_18

MATHEMATICAL MODEL OF TURIN WATER DISTRIBUTION SYSTEM



The aim of the research project was to develop a numerical model of the Turin water distribution network (WDS). A well calibrated WDS model allows the water company to perform analysis, improvement and advanced management of the real network. Some of the possible applications include energy optimization, study of risk and emergency scenarios, subdivision of the network into district metered areas (DMA), modelling of chemical transport, definition of zone of influence, water aging evaluation, etc.

In the scientific literature, mathematical modeling is referred to as the basic requirement for applying innovative methods to water supply network analysis, management, maintenance and improvement. Indeed, in recent years the most advanced water companies started to invest resources in elaborating water network numerical models. The Turin WDS model is developed in the EPANET environment, in order to be as simple and versatile as possible.

One of the first results was the validation of all data used for the model construction. In order to simplify the complexity of the pipe network without affecting the mathematical model, we developed a hydraulic based skeletonization algorithm able to build a mathematical model of the water distribution network closely representative of the real network.

In order to calibrate the mathematical model, that encompasses heterogeneous network and pressure characteristics, a set of flow measures in the distribution network was executed. The results obtained were positive and showed that, despite the uncertainties present and the complexity of such a large system, it is possible to obtain a model that simulates the real behavior of the network with a good approximation. The model obtained represents a starting point for further improvements.

STATUS
Closed

STARTING DATE
January 2016

DURATION
24 months

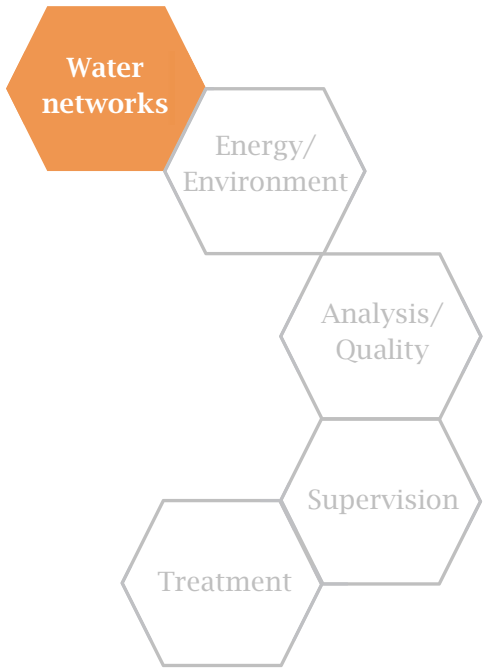
FUNDING
No

PARTNERS
Polytechnic University of Turin

"...in recent years the most advanced water companies started to invest resources in elaborating water network numerical models"

Cod: LRC_AC_2016_05

THE BEHAVIOR OF A SEWAGE SYSTEM IN THE EVENT OF HEAVY RAINFALL



This research project had the goal to understand the behavior of a "storm sewage system" in the Borgo Dora district, Turin.
This choice was made as a consequence of a severe summer flooding occurred as a result of a heavy rainfall event.
Three main activities were carried out:
- modelling of the sewage system and reconstruction of the rainfall event
- evaluation of the drainage system response with different return periods
- elaboration of suggestions for structural interventions to ensure the district safety

The sewage system modelling and the reconstruction of the rainfall event allowed to test the numerical model reliability (the flooded areas were known) and to understand the weaknesses of the sewage system.

The modelled sewage system was tested considering events with different return periods. This allowed to understand which are the critical areas and at which rainfall amounts the sewage system may collapse.

These results allowed to propose different structural interventions to ensure Borgo Dora district safety. Different solutions were considered and evaluated in terms of efficacy and feasibility, giving rise to a list of priorities.

Following the project output, two structural interventions have already been planned in order to overcome current weaknesses of the Borgo Dora sewage system.

STATUS
Closed

STARTING DATE
September 2016

DURATION
9 months

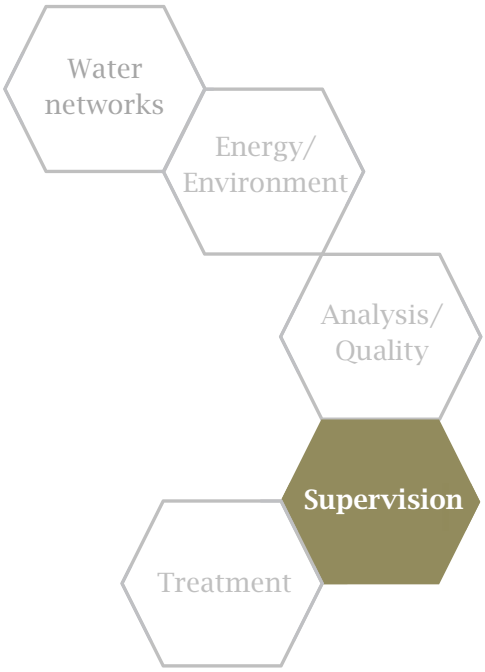
FUNDING
No

PARTNERS
Polytechnic University of Turin

"Understand which are the critical areas and at which rainfall amounts the sewage system may collapse"

Cod: LRC_FD_2017_04

SMART DISINFECTION APPLIED TO DRINKING WATER DISTRIBUTION SYSTEMS



The main purpose of the project is to optimize the control of chlorine dynamics in the distribution network, therefore improving the chemical, microbiological and organoleptic characteristics of distributed water. The control system built during this project allowed to rationally control free chlorine concentration on the whole drinking water network, in order to guarantee the minimum required concentration to ensures proper water disinfection. In case of accidental and/or intentional events of contamination, it will be possible to prevent the distribution of water by rapid identification of the potentially involved areas, namely the ones where an anomalous chlorine consumption is observed.

The first part of the project was dedicated to the study, design and implementation of the monitoring network of chlorine meters. During the subsequent steps, calibration of the numerical model of drinking water quality was carried out, using data deriving from the meters already connected to SMAT SCADA platform.
During the final phase, an automated warning system was developed based on the identification of anomalies arising from the comparison of the measured data with those provided by the numerical modeling (that takes into account chlorine decay in the distribution network). A graphical user interface was also implemented to allow the visualization, with the support of satellite images, of the average values of the measured parameters modeled on the territory.

The experience developed during this study opened the way for a new project that will be developed on Rivoli and Turin distribution networks with the goal of building a quality-related early warning system for supplied water.

STATUS
Closed

STARTING DATE
December 2014

DURATION
36 months

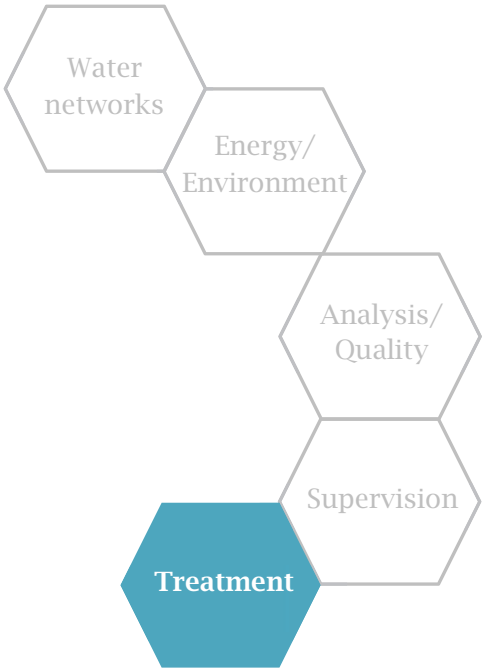
FUNDING
No

PARTNERS
Hera, Iren, Polytechnic University of Turin

"The main purpose of the project is to optimize the control of chlorine dynamics in the distribution network, therefore improving the chemical, microbiological and organoleptic characteristics of distributed water"

Cod: LRC_AC_2014_03

INNOVATIVE TREATMENTS IN THE WATER SUPPLY SYSTEM: EXCLUSION ZONE



It has been extensively observed that, when solutions or suspensions are in contact with hydrophilic surfaces, particles migrate away from these surfaces, leaving a region of 'pure-water' called Exclusion Zone (EZ). This particle-free zone extends from the surface interface up to hundreds of micrometers.

In a previous lab-scale trial, the efficacy of the exploitation of the EZ phenomenon (using Nafion® as hydrophilic material) for removing different chemical and biological pollutants was verified.
This research project had the goal to deepen the Exclusion Zone phenomenon comprehension evaluating:

- the possibility to scale-up the laboratory prototipes already tested for the EZ phenomenon study;
- the increase of prototype efficiency evaluating a better geometry of the different components;
- the exploitation of hydrophilic materials other than Nafion® for real-scale applications.

The experimentation enabled a deeper understanding of the applicability of the Exclusion Zone phenomenon for removing pollutants in aqueous matrices.
Different hydrophilic materials were tested (special attention to PEGDA) and good results in microspheres separation were obtained (comparable to those obtained when Nafion® was used). These materials are not commercially available as tubes or membranes, so a specific formulation to perform a surface coating over dedicated supports was developed.
At present, the technology that exploits the EZ phenomenon is not available for applications others than those useful for lab and research activities, for reasons related, for example, to separation process efficiency scalability (current configuration is based on a multi-channel lab prototype).

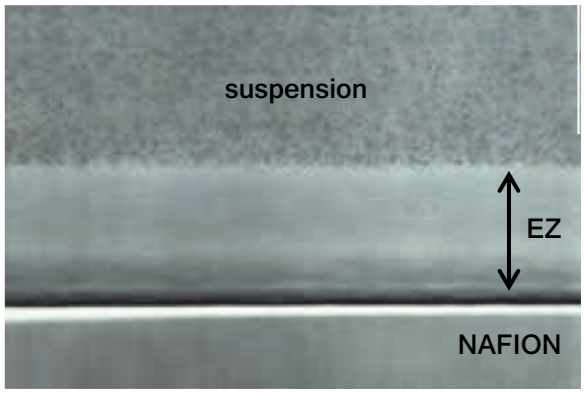
STATUS
Closed

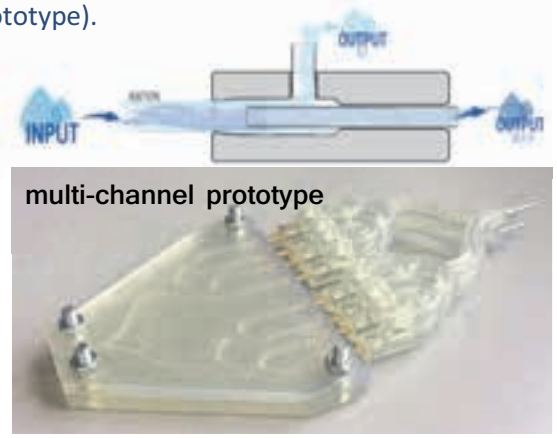
STARTING DATE
December 2015

DURATION
18 months

FUNDING
No

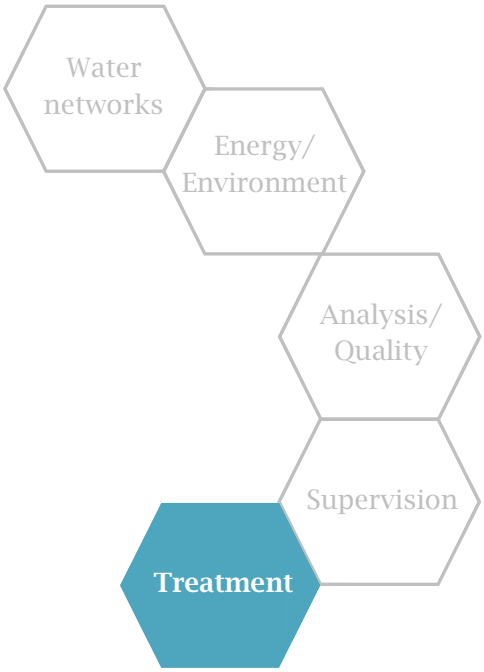
PARTNERS
Polytechnic University of Turin





"The EZ phenomenon is normally observed when solutions or suspensions are in contact with hydrophilic surfaces. Particles migrate away from these surfaces, leaving a region of particle-free water, from which 'pure-water' can be extracted"

SLUDGES



Sludge disposal represents one of the highest expenses for waste water treatment plants. Optimization of sludge treatment processes, especially anaerobic digestion, would be highly desirable to increase biogas production (and consequent co-generation of electrical and thermal energy) and to reduce the amount of solid digestion products and their deriving drying and disposal costs. This theme was by this project in collaboration with the Polytechnic University of Turin, aimed at identifying and testing more efficient plant and process solutions to be applied in the sludge treatment line at the waste water treatment plant in Castiglione Torinese.

During a previous project on the same topic, the optimal condition for low temperature thermo-chemical surplus sludge treatment was studied (lab scale batch digestion tests of 5 liters) with the goal of increasing biogas productivity and removal of sludge organic matter.
Based on the results of these tests, a larger pilot scale test was performed with a 300 L digester with semi-continuous feeding of thermo-alkaly treated surplus sludge.
The pilot test, which lasted around 400 days, was initially performed with untreated sludge (control condition), followed by treated sludge feeding that highlighted an increase of 87% of methane productivity. During the final phase, the pilot plant was fed with treated surplus sludge mixed with untreated primary sludge, simulating the feeding condition that would happen in a full scale application of the process.
The experimental results were extremely satisfactory, revealing biogas productivity comparable to that achieved by state-of-the-art technologies that normally require much higher temperatures and pressures for thermal treatment of surplus sludge.
Lastly, a technical-economic feasibility study was conducted for the evaluation of costs and savings achievable with the full scale application of the proposed technological solution.

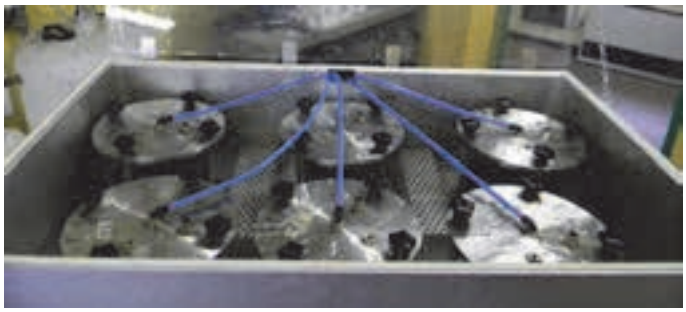
STATUS
Closed

STARTING DATE
January 2016

DURATION
18 months

FUNDING
No

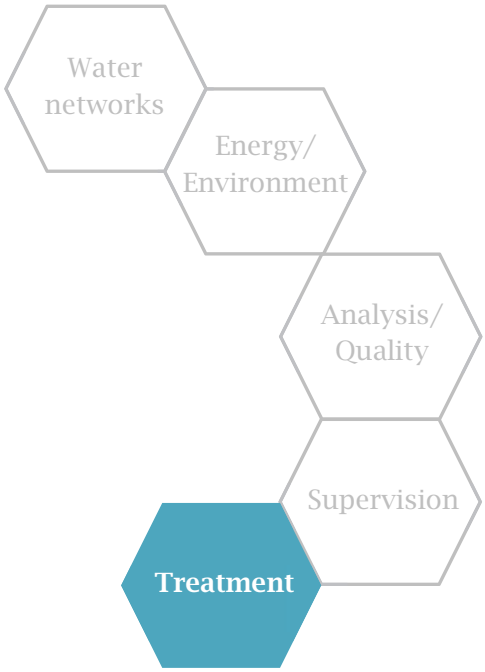
PARTNERS
Polytechnic University of Turin



"Optimization of sludge treatment processes, especially anaerobic digestion, would be highly desirable for an Integrated Water Service Company"

Cod: LRC_FD_2016_11

MEMBRANES FOR CHROMIUM VI REMOVAL



Heavy metals can be found in potentially dangerous concentration at the inlet of drinking water production plants. Their presence is mainly due to agricultural, industrial, mining and transportation activities. Sometimes, pollutants can also be natural.
Recently, a Ministry Decree that set a new parametric value for hexavalent chromium at 10 µg/l has been published. It is a precautionary limit and it will entry into force on January 2019.
In this framework, SMAT has started a project in collaboration with the Polytechnic University of Turin, in order to test the efficiency of membranes in chromium removal processes. This process would be less onerous than reverse osmosis and could be a valid alternative to ionic exchange processes.

The 2-years project was conducted both in the laboratory, in order to characterize and evaluate commercially available membrane performances, and in the field, by means of a real scale application. Part of the project was devoted to the design of a new type of membranes, produced ad hoc in order to solve issues occurred with commercially available membranes.

Laboratory research allowed to better understand the behavior of 3 types of commercially available membranes in order to be able to define, case-by-case, the better choice according to inlet water quality. Thanks to the pilot application, it was possible to assess the actual performances of the membranes and their related criticalities.

A series of polysulphones and sulfonates polysulphones were synthesized with different degree of functionalization, but the resulting polymers are not dense enough for nanofiltration classification.

STATUS
Closed

STARTING DATE
January 2016

DURATION
24 months

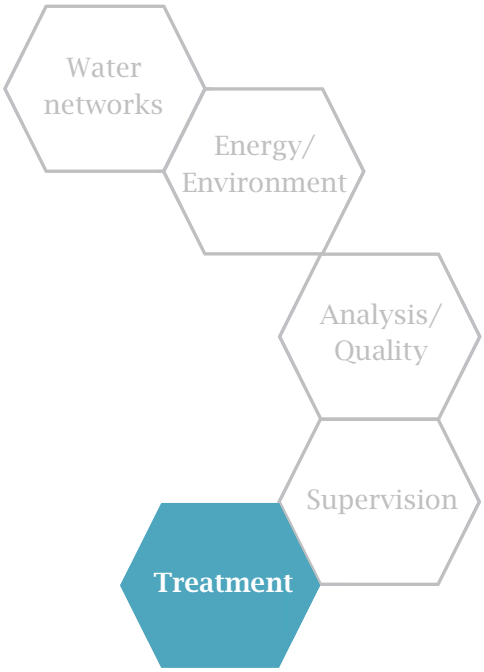
FUNDING
No

PARTNERS
Polytechnic University of Turin

"Nanofiltration could result in a good alternative to ionic exchange processes for hexavalent chromium removal, at lower costs than reverse osmosis"

Cod: LRC_AC_2016_07

HYDRODYNAMIC CAVITATION



Cavitation in a liquid takes place when, due to external conditions, vapor bubbles are formed, as a consequence of the positive difference between saturated vapor pressure and local pressure within the liquid itself. The subsequent recovery of original pressure conditions and the implosion of unstable bubbles results in local temperatures up to thousands degrees and pressures of several atmospheres, without any significant change in the overall characteristics of the bulk liquid. Extreme local temperature and pressure conditions, generated by bubble collapse at the microscopic level, explain the disinfection capacity of hydrodynamic cavitation.

The main project objective was to design, implement and optimize innovative reactor prototypes, able to exploit hydrodynamic cavitation effects for water disinfection purposes. The first reactors were developed and installed within a pilot plant, specifically created to study the main process operational variables. The overall system effectiveness was tested through analytical methods employing methylene blue as a chemical indicator and a variety of bacterial suspensions to assess its biocide power.

The experiment revealed some controversial effects, whose interpretation was not straightforward, as the main variables influencing the process were found to be complex and interdependent. As an example, the study brought out a temperature increase of the treated water mass, probable biomass disaggregation effects and a strong influence of the mixing and recirculation treatment duration.

Given the promising project outputs, a new project, involving additional partners and external funding was started at the end of 2017.

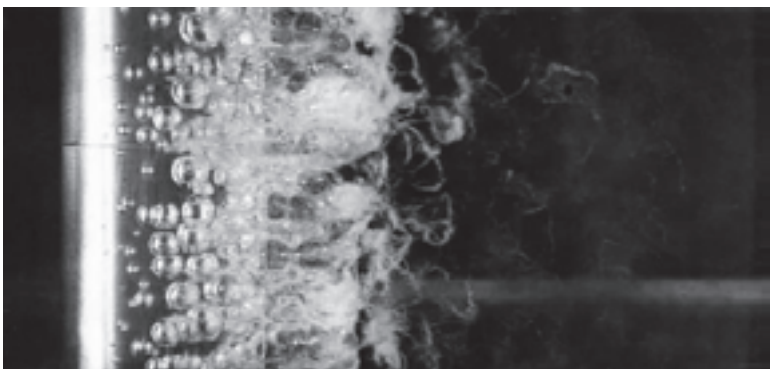
STATUS
Closed

STARTING DATE
November 2015

DURATION
24 months

FUNDING
No

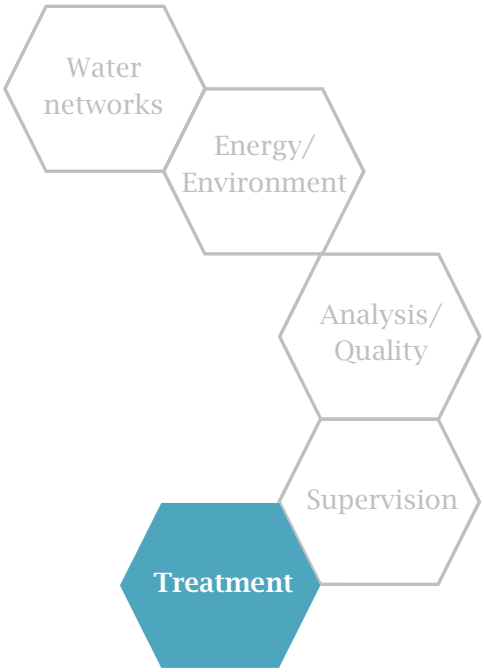
PARTNERS
Polytechnic University of Turin



" Extreme local temperature and pressure conditions, generated by vapor bubble collapse at the microscopic level, explain the disinfection capacity of hydrodynamic cavitation"

Cod: LRC_AC_2016_06

MODELING OF URBAN WASTE WATER TREATMENT PROCESSES



The software GPS-X, based on the model ASM developed by IAWPRC (Henze 1987, Gujer et al, 1999), was applied to model the water line of SMAT wastewater treatment plant in Castiglione Torinese. The model allows to optimize the plant operation, thus assuring effluent quality requirements, reducing operating costs and developing adequate plant control strategies. Given the plant complexity (four modules, built at different stages), the project focused on the three "first generation" modules, with a traditional pre-denitrification scheme.

During the first phase of the project, design data were collected and operational data from several years were processed. Field surveys and sampling campaigns for laboratory analysis were carried out to gather all necessary information for the model elaboration. Data concerning wastewater to be treated were classified according to four general scenarios, based on organic load (medium/high) and meteorological conditions (dry/rain). Starting from these assumptions, the model was built both for dynamic and stationary conditions.

The quality of the model was evaluated by comparing the deviations between simulation results and field measurements of SST, COD, NH4 and NO3. Also energy consumption models were calibrated. Result uncertainty was quantitatively assessed using Monte Carlo statistical analysis. The management optimization based on the model was elaborated for each scenario, as the sludge age conditions varied. Plant efficiency verification criteria were considered in terms of both compliance with limit values for the effluent and performance of secondary settlers.

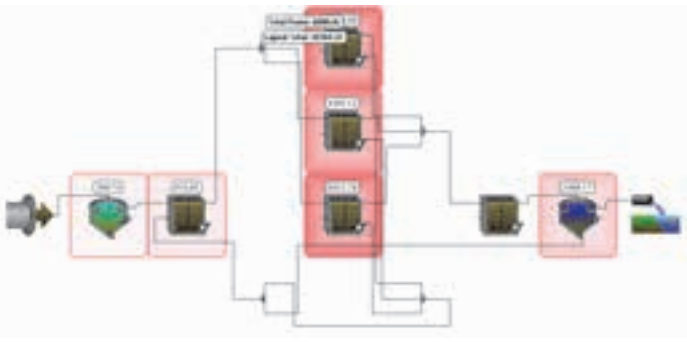
STATUS
Closed

STARTING DATE
January 2016

DURATION
24 months

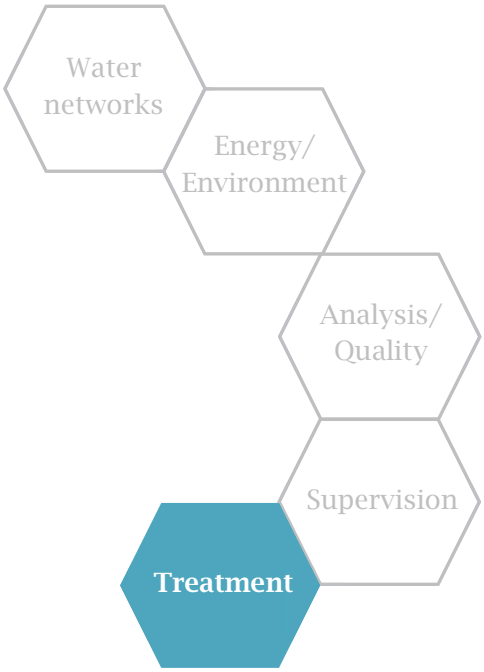
FUNDING
No

PARTNERS
Polytechnic University of Turin



"Traditional modules of the water line in Castiglione wastewater treatment plant were modeled through GPS-X software, based on detailed operational information. This led to the development of management optimization scenarios, depending on variations in sludge age"

COAGULATION-FLOCCULATION UNIT MODELLING OF THE RIVER PO DRINKING WATER TREATMENT PLANT



Plant process control upgrade through the introduction of novel technologies leads to deep changes: from direct human monitoring to control operations that can be carried out remotely. Process automation is driven by different factors such as efficiency improvement, greater stability and reliability as well as cost reduction. The availability of reliable mathematical models able to reproduce and connect the different units of a drinking water treatment plant helps to optimize operating conditions and to evaluate different factors such as quality, costs and environmental impact. This approach allows the optimal utilization of existing infrastructures, providing a useful decision-making support tool.

The goal of this research project, conducted in collaboration among the Polytechnic University of Turin, the SMAT Research Centre and the operative line of the river Po drinking water treatment plant, is to develop a mathematical model of the coagulation-flocculation unit of the PO3 operative line.
The methodological approach of empirical modelling was chosen, by analyzing the correlation between different parameters such as temperature, pH and coagulant dose and the turbidity registered after the coagulation-flocculation process ("output" turbidity). The results of this correlation analysis allowed to identify the parameters having major contribution to describe the "output" turbidity, using the Response Surface Methodology to find the empirical equations that describe the time series of the forecasted variable.

The final implementation of this forecast model at the river Po plant SCADA will provide the operator on duty with the optimal coagulant dose required to maintain turbidity at the outlet of the flocculation process within a defined operational threshold.

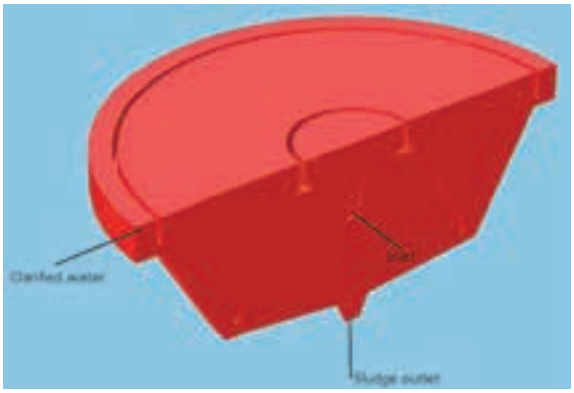
STATUS
Closed

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

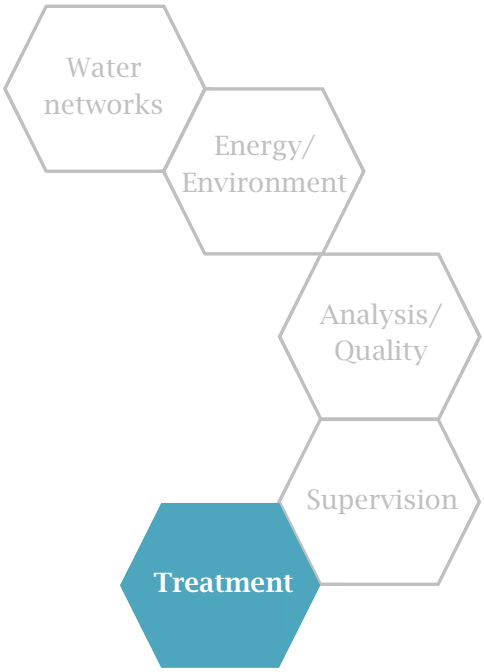
PARTNERS
Polytechnic University of Turin



"The availability of reliable mathematical models able to reproduce and connect the different units of a drinking water treatment plant helps to optimize operating conditions using existing infrastructures, providing a useful decision-making support tool"

Cod: LRC_2016_12/B

WATER TREATMENT THROUGH PHOTOCATALYSIS AND SOLAR ENERGY



Advanced Oxidation Processes (AOPs) are raising a growing interest in the scientific community, thanks to their effectiveness in removing emerging pollutants compared to traditional treatment processes. The purpose of this project is to assess photocatalysis performances in water treatment, with a particular focus on the employment of solar irradiation. Photocatalysis takes place in a solid catalyst (in this case titanium dioxide) activated by solar light and can be exploited to promote the degradation of a variety of pollutants found in water until mineralization.

The project initially focused on testing different setup solutions to assess the treatment effectiveness, with both supported and suspended catalyst medium. A number of operational variables were taken into consideration, including volume concentration of the catalyst, exposure time, radiation intensity and water sample thickness.

During the second phase of the project, an innovative setup was designed and tested. The new plant is able to provide a continuous flow of treated water, in order to provide a low cost solution.

Devices based on porous and hydrophilic materials were tested for different superficial concentrations of catalyst microparticles exposed to the radiation. Finally, the project team performed a trial with chemical and microbiological pollutants, in order to identify optimal operational conditions for the first pilot plant.

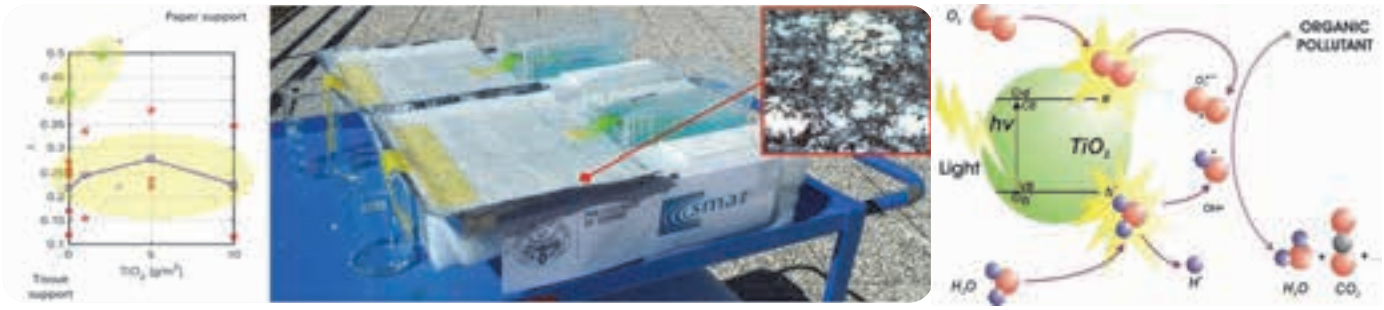
STATUS
Closed

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

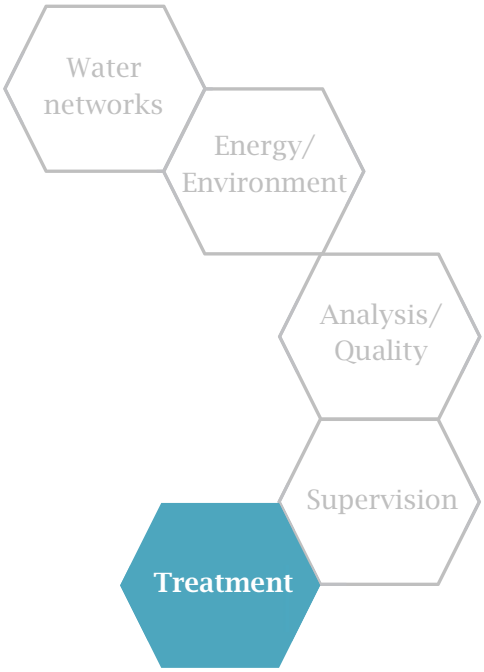
PARTNERS
Polytechnic University of Turin



"The purpose of this project is to assess the effectiveness of solar light-activated photocatalysis phenomena in sustainable and low cost engineering solutions"

Cod: LRC_AC_2016_16

ASSESSMENT OF GRANULAR ACTIVATED CARBON ADSORBING CAPACITY



The purifying properties of charcoal have been well known since ancient times. Its first application for drinking water dates back to 1800, when it was used in England to remove odours from water. The assessment of activated carbon adsorbing capacity is based on specific indicators like benzene, molasses, iodine and methylene blue. Each indicator reveals the capacity of activated carbon to adsorb molecules of different sizes and nature (organic or inorganic). The main objective of this project is to assess the site-specific (i.e. in SMAT drinking water treatment plants) adsorbing capacity of granular activated carbon for the removal of organic micro-pollutants (organohalogen compounds and pesticides).

Specific adsorbing capacity was found to vary significantly among the different filters installed in a plant and among different plants. Differences among different filters in the same plant may be due to non-uniform distribution of inlet flows to the filters or to different load losses related to a lower quantity of filtering medium in the filters. The unique criteria to define cycles for the substitution of exhausted carbon was to consider the overall amount of pollutants passing through the filters (concentration x flow) rather than their concentration in water. For carbon regeneration in the presence of non-regulated organohalogen compounds, we compared values adopted by different entities (WHO, Drinking Water Guidelines; USEPA, EFSA, etc.) and activated threshold values to send alarms related to water quality monitoring.

The study of activated carbon adsorbing capacity can be extremely useful to compare its properties to those of other innovative substrates (e.g. biochar) that will be investigated more in depth during a new ongoing project (LRC_AC_2017_02).

STATUS
Closed

STARTING DATE
November 2016

DURATION
12 months

FUNDING
No

PARTNERS
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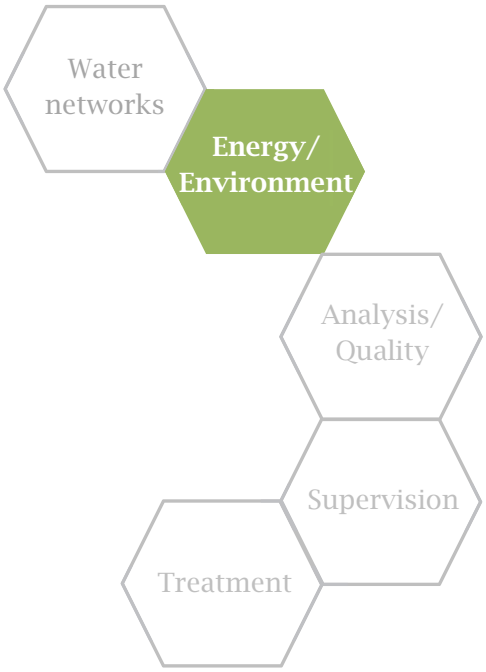
"The assessment of granular activated carbon adsorbing capacity will allow to optimize regeneration intervals and to review the exhaustion criteria used for non-regulated pollutants"

Cod: LRC_AC_2016_20

Ongoing projects

IMPACTS OF CLIMATE CHANGE ON GROUNDWATER RESOURCES



The vulnerability of water resources due to climate change affects water availability both in qualitative and quantitative terms, water-demand management and infrastructural system planning. Climate change adaptation is one of the main challenges that integrated urban water management will be facing in the near future.

The main goals of this research project will be:

- the estimation of the vulnerability of groundwater resources intended for human consumption in the Turin area to climate change effects. This vulnerability will be explored both in quantitative (water availability) and qualitative (maintaining of physical and chemical characteristics) terms;
- the forecast (in probabilistic terms) of the trend of this vulnerability on a time scale of ten to twenty years.

The different quantitative terms of water balance (balance between input and output of water in the soil) have been estimated over the whole geographical area managed by SMAT (meteorological datasets, water-soil-vegetation modelling, hydrometers). The statistical and trend analysis, together with the correlations between the water balance terms and the meteorological variables, have been also evaluated.

A geochemical characterization of the aquifers will be carried out to estimate the qualitative groundwater status (together with the background environmental value for some defined parameters and locations).

Considering two CO_2 emission scenarios (and 5 different climate model projections), the probabilistic evolution of the meteorological variables linked to the water balance terms and to quality parameters will be estimated (2031-2050).

Different aquifer evolution scenarios will be outlined. These probabilistic scenarios will form the quantitative basis for the definition of future SMAT guidelines and strategic developments, for both infrastructure planning and water management and provisioning.

STATUS
Ongoing

STARTING DATE
August 2016

DURATION
30 months

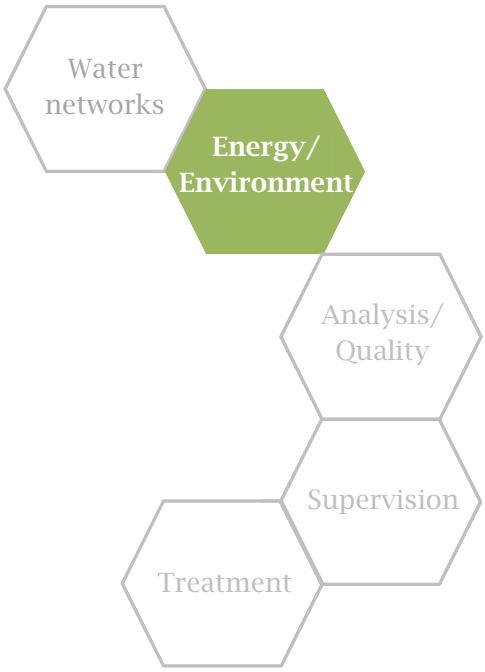
FUNDING
No

PARTNERS
CNR-IGG, DIST, ARPA Piemonte, Società Meteorologica Italiana ONLUS, Regione Piemonte

"Climate change adaptation is one of the main challenges that integrated urban water management will be facing in the near future"

Cod: LRC_2016_19

DEMOSOFC



Biogas produced by the anaerobic digestion of sludges from urban wastewater treatment is characterized by high heating power. This property makes it particularly suitable for the production of electricity and thermal energy. Currently, the most common systems for energy recovery from biogas is represented by boilers or internal combustion engines coupled to electricity generators.
DEMOSOFC aims to demonstrate the real scale feasibility of innovative systems based on solid oxide fuel cells (SOFC). This new technology would allow higher electrical productivity and lower emissions by exploiting a highly efficient electro-chemical process, which is virtually free from pollution production.

Before being used as fuel in SOFC generation cells, biogas needs to be pre-treated in order to remove pollutants, especially sulfur compounds and silicon (siloxanes). The use of biogas from sludge digestion was already tested at a pilot scale by SMAT, in collaboration with the Energy Department of the Polytechnic University of Turin, during the European project SOFCOM.

DEMOSOFC, also co-funded by the EU within the Horizon2020 framework program, foresees the installation of 3 modules of 58 kWe each, at the SMAT treatment plant in Collegno (TO). Currently, this represents the largest SOFC cells installation in Europe and the largest installation worldwide with SOFC cells powered by biogas.

In October 2017, the first of the three modules was switched on. It shows high electrical efficiency (54%-56%) and extremely low emissions. Once fully operational, DEMOSOFC will be able to cover up to 25%-30% of the treatment plant's electrical needs.

STATUS
Ongoing

STARTING DATE
September 2015

DURATION
60 months

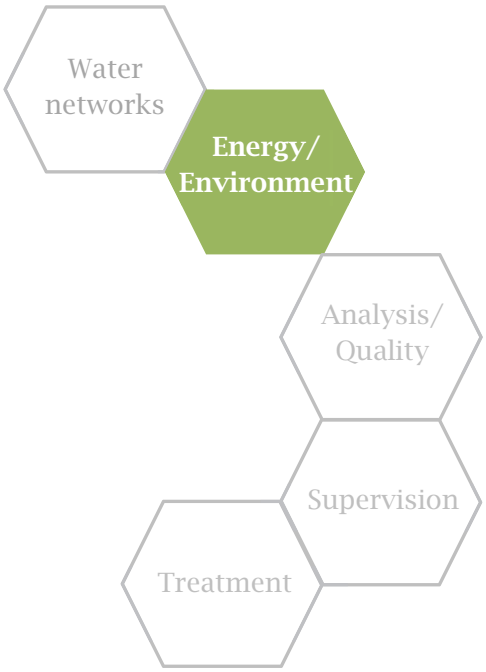
FUNDING
Yes

PARTNERS
Polytechnic of Turin, Convion Oy, VTT, Imperial College, Risorse Idriche

"The first SOFC module for energy generation at high efficiency and zero emissions through solid oxide fuel cells powered by biogas from sludge anaerobic digestion was installed at the SMAT water treatment plant in Collegno"

Cod: LRC_FD_2015_07

MODELING THE ATMOSPHERIC DISPERSION OF ODOR-PRODUCING SUBSTANCES



The local acceptability of a large wastewater treatment plant, like the one serving Turin and its outskirts, requires an ever-increasing attention to the containment of odor-producing substances propagation.

The objective of this research project is to assess the impact of odor emissions from the treatment plant in Castiglione Torinese on the surrounding environment; the model to be elaborated is intended to allow the identification of containment actions that will integrate the three deodorizing sections already installed within the plant.

The implementation of the odor dispersion model implies the creation of an integrated system including the following sections:

- A station for continuous monitoring of local meteorological conditions;
- A network for the measurement of odor-producing substances in the air
- A modeling chain, to integrate measures from the monitoring network with meteorological information in order to simulate the dispersion phenomenon and provide a real-time updated cartography showing the area affected by emissions.

During the first phase of the project, the meteorological station was installed. A study finalized to the creation of the odor monitoring network was also carried out.

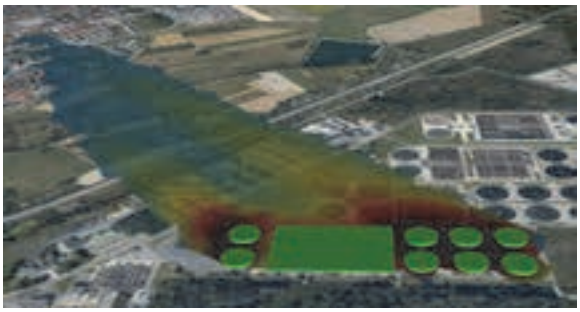
STATUS
Ongoing

STARTING DATE
March 2017

DURATION
24 months

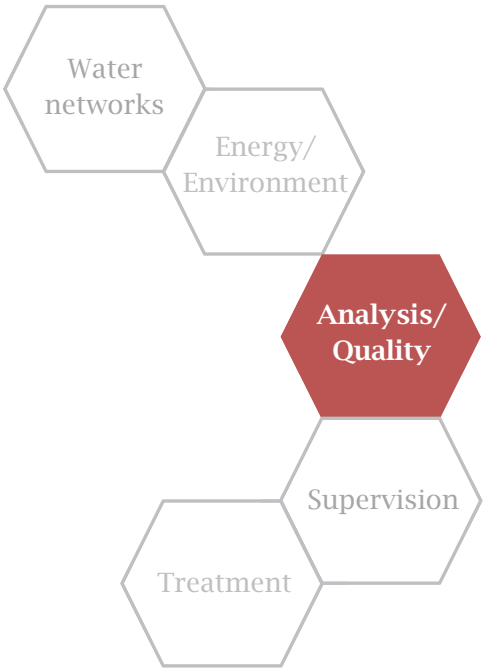
FUNDING
No

PARTNERS
Polytechnic of Turin, Ecole Centrale de Lyon, Società Meteorologica Italiana ONLUS



"The objective of the project is to create a model to assess the impact of odor emissions from the wastewater treatment plant in Castiglione Torinese on the surrounding environment "

BIOCONTAMINATION INTEGRATED CONTROL OF WET SYSTEMS FOR SPACE EXPLORATION (BIOWYSE)



As demonstrated in several years of ground studies and actual space operations, humid surfaces and water recirculation systems are the most prone to microbial contamination. Space exploration requires the development of more reliable, rapid, efficient and safe methods for preventing, monitoring and controlling potential biocontaminations within human confined environments. As a recognized expert in all steps of drinking water management as well as in water production for the International Space Station (ISS), SMAT was invited to participate along with other international partners in a competitive call for proposals and was awarded funding for this project from the European Union within the framework of the Horizon 2020 program.

The BIOWYSE project aims to develop an integrated real-time biocontamination control system within water networks and humid surfaces onboard ISS and for future human space exploration missions. During the second year of work, SMAT was involved in the calibration and validation of the two key components of the prototype: the monitoring module, based on the fast, sensitive and innovative technology of bioluminescence, and the decontamination module, built of high efficiency ultraviolet lamps. Test conditions included multiple experimental setups and several water types with different degrees of contamination and were helpful to set the performance limits and the best operational modes to be applied in space. SMAT is now investigating the behavior of the prevention module (a silver-coated tank, with antimicrobial properties) to proceed to the assembly phase and to the field tests by the end of 2018. The device could also have a potential for commercial exploitation on Earth, in applications such as confined habitats, hospitals and water distribution networks.

STATUS
Ongoing

STARTING DATE
December 2015

DURATION
36 months

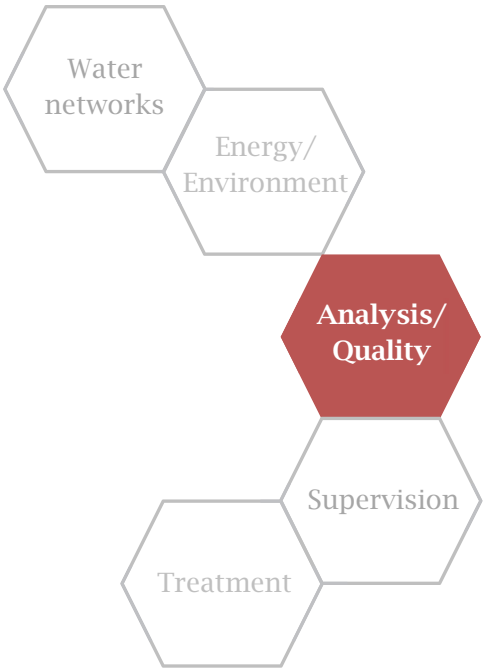
FUNDING
Yes

PARTNERS
ESF, TAS-I, CNR, GLBio, Liewenthal Electronics, UniFi, A-ETC, AquiSense

"The project aims to develop an integrated real-time biocontamination control system within water networks and humid surfaces onboard ISS and for future space exploration missions"

Cod: LRC_AC_2016_01

EMERGING POLLUTANTS ANALYSIS IN DRINKING WATER



The project aims to investigate the presence of emerging pollutants (EPs) in drinking water supplied by SMAT. The word EPs refers to a variety of chemical compounds including pharmaceuticals, cosmetics, pesticides, perfluoroalkylated substances, haloacetic acids, derived from different human activities.

The European Commission Implementing Decision 2015/495 establishes the list of substances to be monitored, in agreement with the indications provided by the WHO. The most frequently found substances will probably be regulated in the near future. SMAT laboratories have been equipped with the instrumentation necessary for the identification and quantification of priority substances, subject of this research project.

The initial phase of the project focused on the setup and optimization of the separation technique (HPLC/MS/MS) for the following classes of pollutants:

Pharmaceuticals: these include hormones, Diclofenac, Ibuprofen, Ketoprofen, Clarithromycin, Erythromycin, Methiocarb and Caffeine.

Endocrine Disruptors: these pharmaceutical compounds and their metabolites, which are widely used, include 17 α-ethinylestradiol and β-estradiol hormones

Glyphosate and metabolites: pesticides widely used in place of or in conjunction with those historically used (eg: atrazine and derivatives).

Pesticides: almost a hundred active ingredients and metabolites that will increase the number of molecules currently monitored by GC/MS/MS.

Perfluoroalkyl substances (PFAS): the most toxic are perfluoro-octanoic acid (PFOA) and perfluoro octane sulfonate (PFOS), employed in many industrial activities (Teflon, Goretex ...).

Analytical method validations and wide monitoring campaigns will be carried out during the following phases of the project.

STATUS
Ongoing

STARTING DATE
January 2017

DURATION
24 months

FUNDING
No

PARTNERS
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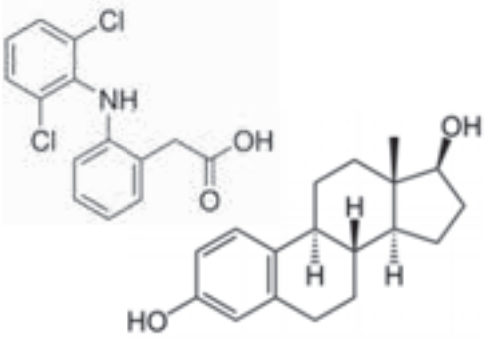
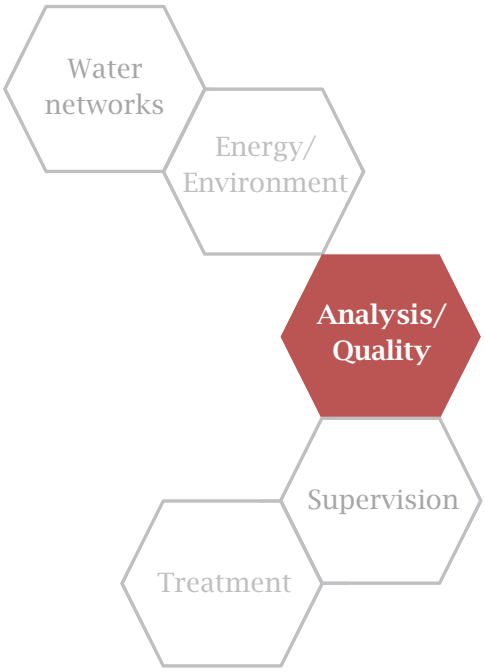


"To investigate the diffusion of pollutants is the first step towards the implementation of mitigation measure to increase consumers' and stakeholders' confidence "

Cod: LRC_AC_2017_05

REAL-TIME ALERT SYSTEMS FOR MICROBIOLOGICAL CONTAMINATION OF DRINKING WATER INTENDED FOR HUMAN CONSUMPTION



The project is aimed at evaluating the applicability of an innovative online water quality monitoring system within distribution networks. The instrument consists of a camera connected to a microscope able to scan a water sample inside an integrated reading chamber. A dedicated software automatically analyzes images by comparing them to a reference database and provides counts of both bacterial and non-bacterial particles per milliliter of sample. The read and the update occur at approximately ten minutes intervals, issuing an almost instantaneous information about water quality.

The instrument was alternatively connected to three drinking water distribution networks of different origin (groundwater and surface water) and with diverse chemical and microbiological characteristics. Each network was monitored from a minimum of 8 to a maximum of 112 days, for a total of more than 20'000 semi-continuous analytical results over a period of 150 days. Whenever possible, real-time results provided by the instrument were compared to those derived from timely samples analyzed in parallel using other laboratory methods (culture and measurement of ATP concentration for the quantification of viable microorganisms). A detailed study of the data series highlighted fluctuation intervals typical of each water type and allowed us to set for all three of them tentative alarm thresholds, above which it would be necessary to follow up with a deeper investigation. Notably, with less than 2% of the values above these thresholds, all of the water networks examined were characterized by high quality standards.

STATUS
Ongoing

STARTING DATE
May 2017

DURATION
12 months

FUNDING
No

PARTNERS
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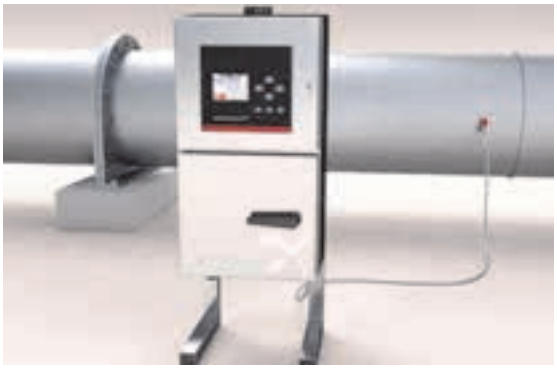
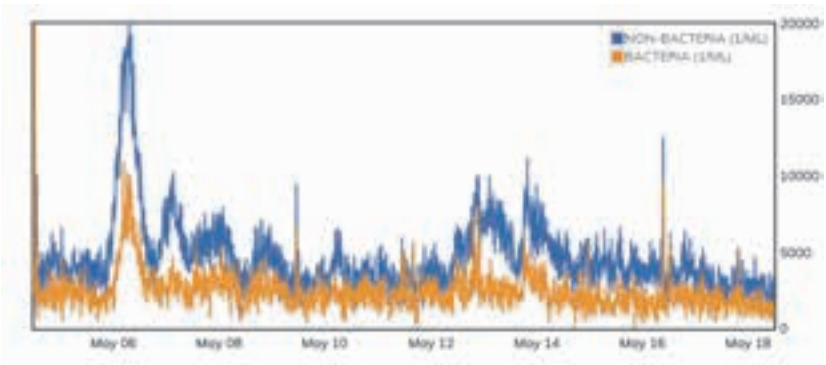
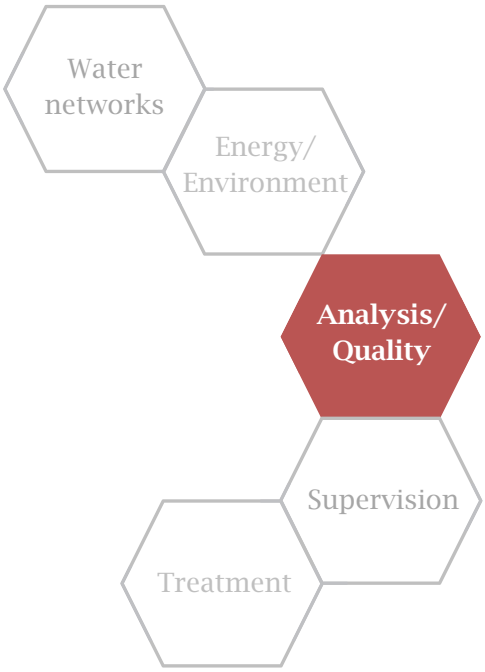




"The instrument consists of a camera connected to a microscope able to scan a water sample, providing counts of bacterial particles inside"

Cod: LRC_AC_2017_10

EVALUATION OF BACTERIAL DNA PURIFICATION METHODS AND SELECTION OF A PCR TECHNIQUE FOR DNA AMPLIFICATION FROM VIABLE CELLS



The list of waterborne microorganisms with a pathogenic potential is long and many diseases can indeed be ascribed to water contamination. Classical microbiology-based culture methods, whenever available, are not always species-specific, are usually long-term (days) and not always straightforward to interpret. For these reasons, back in 2008, SMAT introduced PCR as a first attempt to apply biotechnological methods in parallel with traditional microbiology. Following the recent and substantial advances in the development of molecular methods, it was necessary to improve and optimize the whole process, from sample preparation to the subsequent analytical steps.

The project is aimed at studying the most promising concentration, extraction and purification techniques for bacterial DNA. Nucleic acids could then undergo PCR to amplify selected genomic regions that can allow genus and species identification of the microorganism, with a higher degree of sensitivity and specificity than traditional methods. Using commercial or custom-designed kits generated through biotechnological approaches, the application field includes virtually all microorganisms for which the genomic sequence is publicly available. In the early stages of the project, all efforts focused on the development of a robust procedure to discriminate live (therefore potentially pathogenic) and dead cells by introducing a particular treatment step before PCR, in order to avoid false positive calls in treated water samples. Overall, such a versatile system could be widely employed for different purposes: routine analyses when a prompt response is needed (within the same day), management of emergency situations, search for emerging pathogens, deeper investigation on bacteria involved in water treatment processes and much more.

STATUS
Ongoing

STARTING DATE
December 2017

DURATION
24 months

FUNDING
No

PARTNERS
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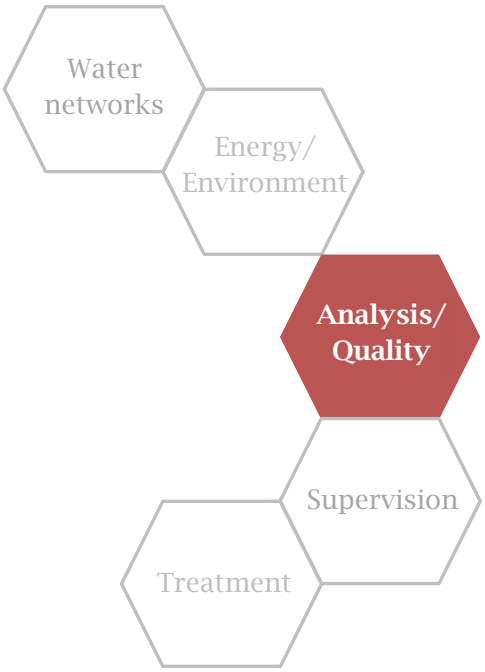
"Using commercial or custom-designed kits generated through biotechnological approaches, the application field includes virtually all microorganisms for which the genomic sequence is publicly available"

Cod: LRC_AC_2017_22

PERSEO - PERSONAL RADIATION SHIELDING FOR INTERPLANETARY MISSIONS



Radiation hazard to the crew is one of the main showstopper for space exploration and passive radiation shielding currently represents the only feasible technology to allow human deep-space missions. The space radiation environment is mainly constituted by Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE), and the exposure to these highly energetic particle fields entails significant risks for astronauts, possibly inducing both acute and long term effects. In particular, SPEs have the potential to deliver high radiation doses, eventually causing the haematopoietic syndrome and compromising the bone marrow. Future long term missions therefore require the definition of appropriate personal protection strategies to ensure adequate security conditions for astronauts' work.

The goal of the PERSEO (PErsonal Radiation Shielding for intErplanetary missiOns) project, funded by the Italian Space Agency (ASI), is to study innovative wearable radiation protection systems to mitigate the effects of cosmic radiation on astronauts. This system, that was produced also thanks to SMAT , which provided designing and building of the bags contained inside the garment, that constitute the shielding part, was tested from the astronaut Paolo Nespoli on the International Space Station on November 7, 2017. During the in-orbit experimental session, the crew evaluated the wearability-related aspects, as well as the simplicity of filling and discharging bags.

Furthermore, water shielding properties will be tested using an ALTEA/LIDAL detector, available on the ISS, on a bag sent to the ISS already full of flight water supplied by SMAT.

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
36 months

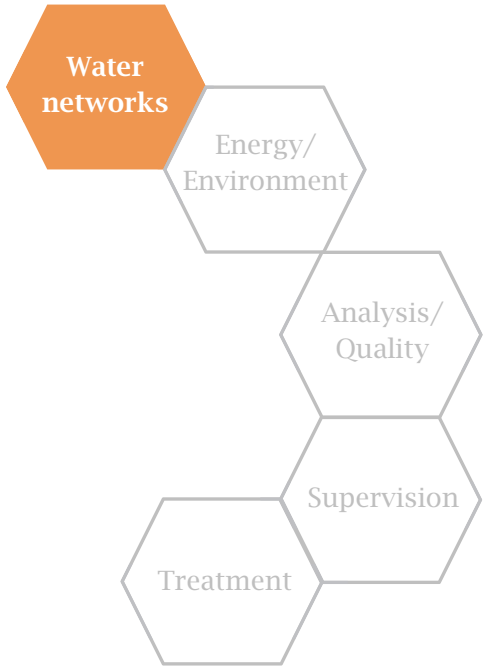
FUNDING
Yes

PARTNERS
University of Pavia, TAS-I, Aviotec, ALTEC, University of Rome Tor Vergata

"Radiation exposure causes both acute and long term effects on astronauts' health. The goal of the PERSEO project is to study and develop innovative wearable radiation protection systems to mitigate the effects of cosmic radiation"

Cod: LRC_2016_02

INNOVATIVE TECHNOLOGIES FOR WATER PIPE CLEANING



Today, one of the main problems for water industries is pipeline cleaning within the distribution network. During normal operating conditions, development of fouling and deposits due to the mutual chemical interaction between water and the pipe material is a common event, representing a fertile soil for microorganisms which feed on the substances that can be found on the internal pipe surface (biofilm). As their thickness increases, fouling and deposits can also compromise normal water flow in pipes. The aim of this project is to verify the efficacy of some innovative cleaning technologies for hydraulic pipelines, validating their effectiveness in the field with a strictly scientific approach.

In this context, in June 2016, a new technology based on the use of a simple mixture made of water and ice was applied to the distribution network of Avigliana. The case study demonstrated good effectiveness in cleaning aqueduct pipes. About 250 kg of solid substances were indeed removed by an operation which required to shut down the duct for only a few hours. Furthermore, it was possible to reactivate the pipe just minutes after the end of operations.

A pilot plant was built at the SMAT Research Center to better understand the mechanisms of water pipe cleaning. This plant consists of a 27 m circuit with 50 mm diameter pipes. Different measuring instruments, able to analyze the dynamic and efficacy of cleaning operations, complete the plant.

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
36 months

FUNDING
No

PARTNERS
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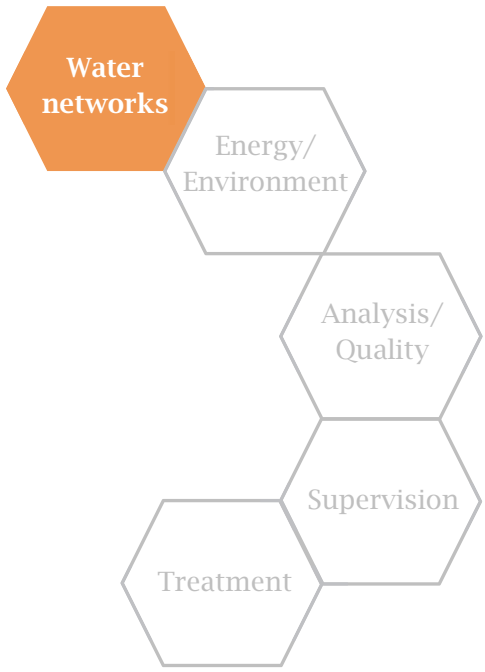
"The aim of this project is to verify the efficacy of some innovative cleaning technologies for hydraulic pipelines, validating their effectiveness in the field with a strictly scientific approach"

Cod: LRC_AC_2016_04

DECISION SUPPORT SYSTEM FOR A PIPE NETWORK REPLACEMENT PROGRAM



The project aims to develop a tool that optimizes the economic resources allocated to water distribution network maintenance through a choice of the pipelines to be replaced based on different criteria: a statistical analysis of breakdown probability, the cost of the replacement and the importance of the pipeline from the hydraulic point of view.

Breakdown causes are multiple, each of them is characteristic of a certain class of materials besides, obviously, the conditions to which the pipe is subjected. In addition to purely chemical phenomena, the stress source can often be a phenomenon which is still rarely measured in water distribution networks, called pressure transients. Pressure transients, that are usually generated by sudden changes in the flow along the pipeline, are high pressure waves that move at high speed along the pipelines and, because of their magnitude, can stress the pipeline.

One of the peculiarity of this research is the use of existing data deriving from different origins. For example, the pressure levels, but also the heavy vehicle traffic density that insists over the pipelines.

The tool that will be developed, in addition to optimally addressing the economic resources allocated to the maintenance of the distribution network, will also ensure a significant reduction in the number of breakages, and therefore of repair interventions, thanks to a greater knowledge of the breaking mechanisms.

STATUS
Ongoing

STARTING DATE
January 2018

DURATION
12 months

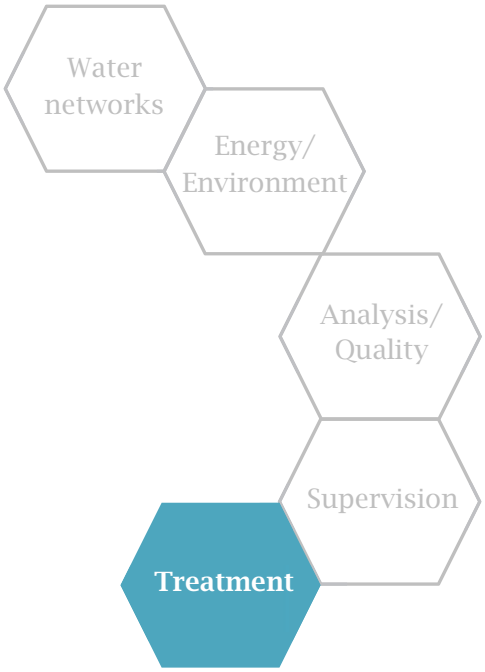
FUNDING
No

PARTNERS
Hera, Iren

"...to develop a tool that optimizes the economic resources allocated to water distribution network maintenance."

Cod: LRC_2017_08

EXCLUSION ZONE STUDY USING NUCLEAR MAGNETIC RESONANCE TECHNIQUES



The presence of the so-called "Exclusion Zone", a water region at the fluid-solid interface in the vicinity of hydrophilic materials where both suspended particles and dissolved substances tend to be rejected from the surface, is of basic scientific interest, but it could be of essential importance for separation and filtration technologies, water purification, fouling prevention and ion exchange chromatography (although the scientific debate for explaining the mechanism responsible for the phenomenon is still open). This is the basis of this research project, carried out with the Biotechnology Department of the University of Turin.

Nuclear Magnetic Resonance (NMR spectroscopy and MRI imaging) allows to study water behavior around molecules within an aqueous solution. With such technologies it is possible to evaluate water molecules mobility and to identify the forces acting on EZ formation.
The technique provides information on a specific sample by "soaking" it in a magnetic field and successively analyzing the resonance frequency spectrum of the hydrogen nuclei of the water molecule. This spectrum is characteristic of the molecular structure of the sample analyzed.
MRI imaging allows the acquisition of pictures of a sample where the color contrast is obtained as a consequence of the different magnetic properties of atomic nuclei (the so-called relaxing time, or the time necessary to return to the initial conditions after the magnetic field "immersion").
Using Nafion for EZ formation, MRI images of a membrane soaked in ultrapure water showed an area of 60 μm around the membrane where signal intensity is intermediate between that of "free" water far from the Nafion and that of the water trapped within the membrane itself. These water molecules have less mobility than bulk water, and this is consistent with a partial water structuring, electrically induced by the Nafion surface.
These results confirm EZ formation and the next steps of this project will allow a deeper understanding of the phenomenon to identify the best possibility to exploit it for waterworks applications.

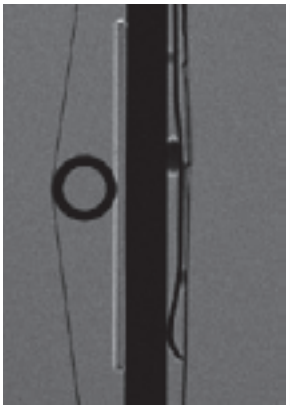
STATUS
Ongoing

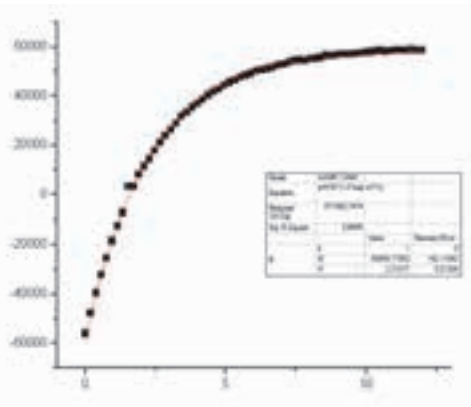
STARTING DATE
February 2017

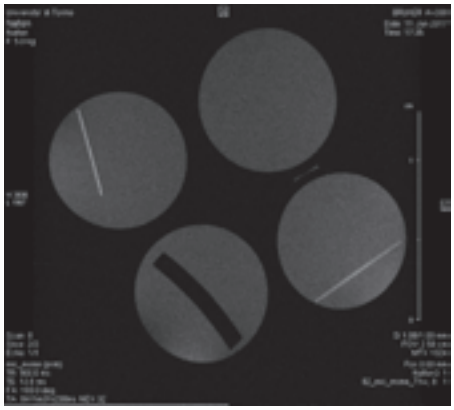
DURATION
24 months

FUNDING
No

PARTNERS
University of Turin



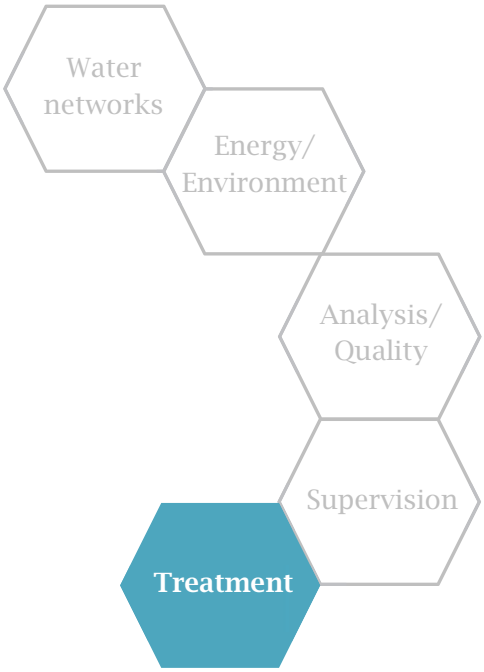




"The presence of an Exclusion Zone where water has less mobility than bulk water was confirmed by Nuclear Magnetic Resonance techniques"

Cod: LRC_AC_2017_01

HALOACETIC ACIDS AND BIOCHAR



Haloacetic acids (HAA) are molecules formed during water purification processes, as a consequence of the reaction between natural organic matter (NOM) and chlorine-based disinfectants. The International Agency for research on Cancer (IARC) has classified four HAA (chlorine and bromine derivatives) in the 2B group (possible human carcinogens): dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), dibromoacetic acid (DBAA) and bromochloroacetic acid (CBAA). Biochar is a carbon-based residue resulting from the thermal conversion of biomass. The project aims to investigate both analytical and environmental aspects related to the determination of HAA and their low cost removal through biochar.

The study is particularly relevant, given the possible inclusion of HAA among the parameters to be monitored as prescribed by the new European Directive concerning water for human consumption.
The extensive literature review performed during the first phase of the project in order to gather information about available techniques for the determination of these molecules, led to the selection of ion chromatography coupled with tandem mass spectrometry (IC-MS / MS).
The second phase focused on the separation technique for ten HAA congeners, with analytical performance levels widely compatible with the limits set by the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA).
Finally, a HAA measurement campaign on real samples started.
During the next phase, different types of biochar will be tested for HAA removal at the laboratory scale.

STATUS
Ongoing

STARTING DATE
January 2017

DURATION
24 months

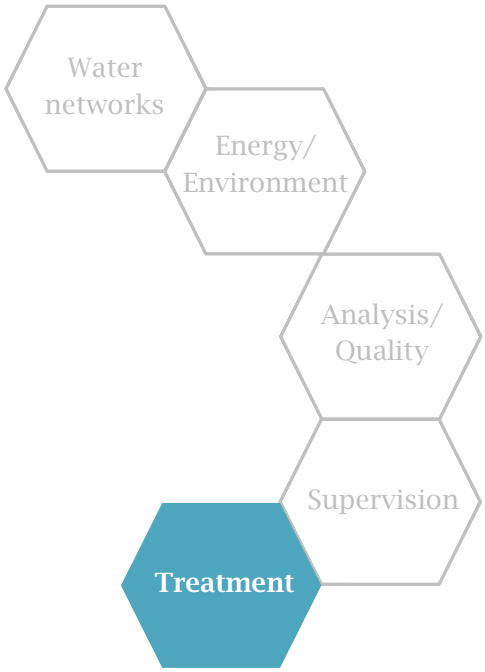
FUNDING
No

PARTNERS
University of Turin

"The chemical-physical characteristics of the biochar are promising for applications in the field of water treatment, while promoting the reuse of biomass (remains of tree-pruning, corn or wheat stubble, rice husk, almond husk, foliage, etc.)"

Cod: LRC_AC_2017_02

HEXAVALENT CHROMIUM TREATMENT PLANTS



In Italy, the future entry into force of the new limit on hexavalent chromium makes it necessary for water utilities to find the best technologies to reduce its concentration in drinking water below 10 µg/l.
The project has the purpose of supporting operational departments in finding best solutions in sites where proper measures should be adopted. The first trial was lead in a municipality with less than 500 inhabitants, a mean average flow of 0,5 l/s and a concentration of hexavalent chromium just above to the future regulatory limit; operating issue are, in this case, fundamental for choosing the best solution since the plant does not have permanent workforce.

The choice fell on Weak Base Anion Exchange (WBA) resins that are used in single-pass mode; they should not be regenerated. Costs are higher but their use is simpler. The experimentation started with an existing equipment that was adapted to the new application; the plant was put in service in mid-June 2017.

The results obtained so far have shown a good resin performance and chromium VI removal at concentration much lower than the future regulatory limit. Further verification is required on filtering material duration in order to complete the cost/benefit analysis.

STATUS
Ongoing

STARTING DATE
March 2017

DURATION
21 months

FUNDING
No

PARTNERS
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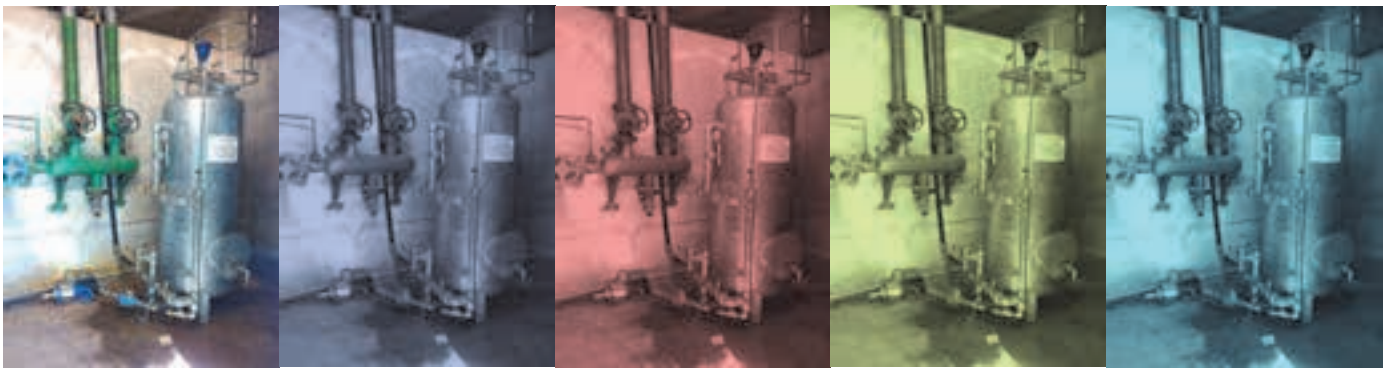
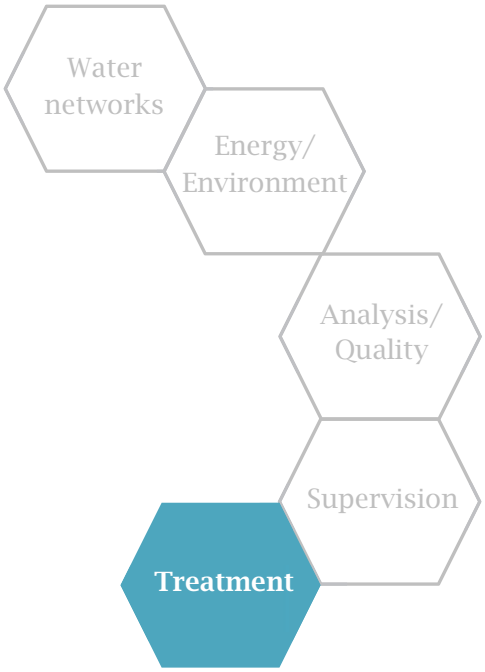


"In Italy, the future entry into force of the new limit on hexavalent chromium makes it necessary to find the best technologies to reduce its concentration in drinking water below 10 µg/l"

Cod: LRC_AC_2017_20

AQUALITY: INTERDISCIPLINAR CROSS-SECTORAL APPROACH TO EFFECTIVELY ADDRESS THE REMOVAL OF CONTAMINANTS OF EMERGING CONCERN FROM WATER



Aquality is an international multidisciplinary academic and industrial network formed by 18 members (7 Universities, 3 Research Institutions and 8 companies) with the purpose to support highly qualified researchers (15 PhD students, of which one will be trained at the SMAT Research Center). The objective of the project is to enable them to face current and future challenges in the protection of water resources from emerging pollutants (training-through-research).
The main research topic is the removal of emerging pollutants from water through environmentally and financially sustainable hybrid treatment processes. An example are sun-driven oxidation processes coupled to membrane filtration systems (new materials, high flow ceramics, etc.)

Researchers will be awarded a PhD in INNOVATION FOR CIRCULAR ECONOMY. This innovative course of studies, promoted by the Italian Ministry of Education, University and Research, was activated one year ago by the University of Turin. It is particularly suitable to the purpose of the project, due to its inter-sectoral and industrial character. In brief, the main research topics to be addressed are:

- Detection and monitoring of emerging pollutants (state of the art in participating countries) and their by-products
- Development of new photochemical materials for filtrating membranes (silicon carbide)
- Study of low energy impact hybrid treatment processes (solar energy coupled to membranes)
- Assessment of pollutants and by-products toxicity

STATUS
Ongoing

STARTING DATE
October 2017

DURATION
48 months

FUNDING
Yes

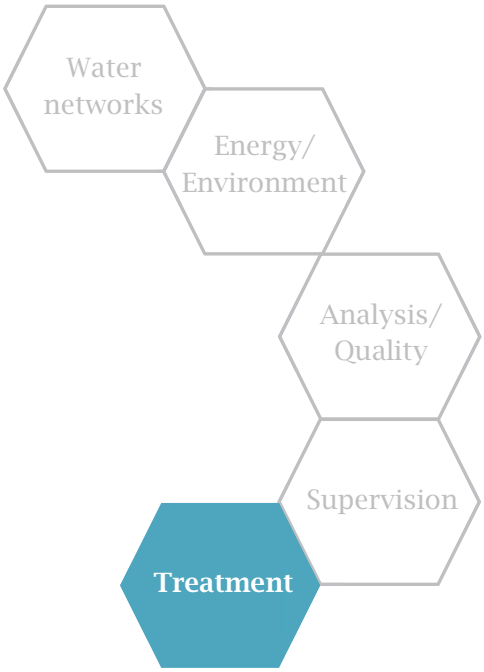
PARTNERS
Univ. Turin Aalborg Universitet, Univ. Eastern Piedmont, Univ. Politecnica de Valencia, et al.

AQUAlity

"The project, thanks to its interdisciplinary and cross-sectoral approach, aims to apply "training through research" to a study on innovative hybrid systems to remove emerging pollutants from water"

Cod: LRC_AC_2017_11

ALGAEBIOUP



A valuable alternative to traditional biogas recovery through cogeneration of electric and thermal power is the so called biomethanation. It consists of the process of biogas purification through the removal of carbon dioxide and other impurities (i.e. sulphydric acid and siloxanes), aimed at producing quasi pure methane that, if meeting the required quality standards, could be introduced into the natural gas distribution grid and used elsewhere, for example for energetic purposes (gas power plants) or transportation (gas powered vehicles).
The most popular technologies for biomethanation are generally based on membrane separation or on CO2 absorption in pressurized water.

The aim of this project is to study and test microalgae cultivation in photobioreactors as an innovative biomethanation technology.
Indeed, microalgae are photosynthetic organisms that use solar energy to absorb CO2 (thus removing it from biogas) which is then transformed into new algae biomass. In our case biogas, likely after a pre-treatment step, would be the source of CO2 for algae. The products of this process would be two: biomethane, originated from biogas purification, and algae biomass witch can be used for different purposes (animal feeding, cosmetics, nutraceutics, etc…).
After the first part of the project, devoted to extensive lab tests for the selection of the most suitable algae species for the specific purpose of the project (in terms of productivity, CO2 removal, best adaptation to the available water-based growth medium and operating conditions), a planar-geometry pilot plant was built for algae cultivation with the aim of biomethane and biomass productivity maximization.
The developed experimental set-up can work with natural or artificial light (with settable intensity and frequency) and allows the regulation of recirculation and biogas flow rate. In this pilot plant we performed several cultivation tests of the selected algae species in different operating conditions and we are, at present, evaluating the production rates of algae and biomethane. During the last months of the project we will evaluate the quality of the biomethane produced by the pilot plant and we will perform a technical-economic feasibility evaluation of the full scale application of the process.

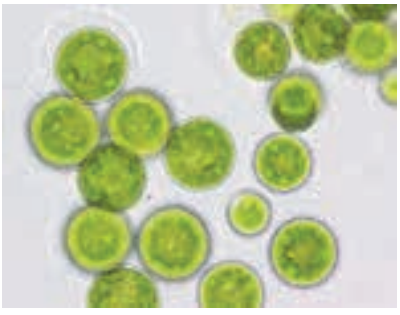
STATUS
Ongoing

STARTING DATE
January 2016

DURATION
30 months

FUNDING
No

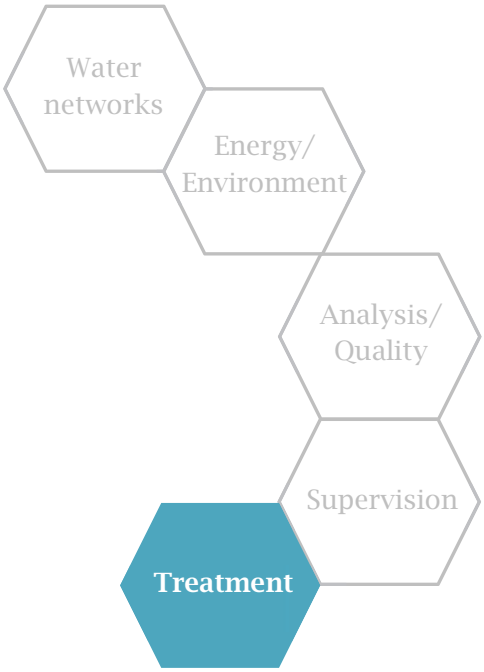
PARTNERS
Polytechnic University of Turin



"The aim of this project is to study and test algae cultivation as an innovative biomethanation technology"

Cod: LRC_FD_2016_13

STRUVITE RECOVERY PROCESSES



Urban wastewater treatment is usually seen as a sequence of physical, chemical and biological processes aimed at the purification of a polluted resource before its return into the environment, with inevitable economic and environmental costs (energy consumption and waste production). Decades of process technology evolution offered, in addition to a continuous improvement of energetic and contaminant removal performances, the possibility to consider wastewater not just as a waste product but as a resource. From this point of view, several technologies have been developed for water reuse, for electrical and thermal energy recovery through biogas production from sewage sludges and for sewage sludge recovery (for agricultural or cement production).

An even more forward-looking approach and a further step along this way is represented by raw material recovery, re-usable as common commercial products with economic and environmental advantages. Several efforts have been deployed for this goal and, at present, one of the most promising applications is phosphorous and nitrogen recovery through struvite production (a salt composed by phosphorous, ammonium and magnesium), via precipitation processes performed in wastewater or sludge treatment lines. Indeed, nutrient recovery from wastewater for agricultural re-use, as a more sustainable alternative to artificial fertilizer, is a fundamental theme from an environmental point of view.

The aim of this project is the evaluation of the technical and economic feasibility of the introduction of struvite recovery technology in some of the wastewater treatment plants managed by the Companies forming the project partnership. Commercially available technologies will be evaluated and compared based on production yields, operating and capital costs and based on compatibility with existing processes and plants. Moreover, a preliminary design of the selected system will be prepared in addition to the evaluation of expected production yields and investment returns over time. These evaluations, when the regulation and market conditions will be favorable, will allow the Companies to program the upgrade of installations for struvite recovery.

STATUS
Ongoing

STARTING DATE
June 2016

DURATION
18 months

FUNDING
No

PARTNERS
Hera, Iren

"Nutrient recovery from wastewater for agricultural re-use, as a more sustainable alternative to artificial fertilizer, is a fundamental theme from an environmental point of view"

Cod: LRC_FD_2017_17

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