Research activities

10

FEBRUARY 2019

smat
CENTRO RICERCHE

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CENTRO RICERCHE

Research activities

FEBRUARY 2019

BS OHSAS 18001:2007
CERTIFICATO N. 9192.MACT

UNI EN ISO 14001:2015
CERTIFICATO N. 9191.SMTO.

UNI EN ISO 9001:2015
SGQ Certificato n. 343

2018: SMAT Research Center 10th birthday!

A very significant year for us just came to an end: on 28th November 2008 SMAT Research Center was inaugurated; ten years later we gathered in Castiglione Torinese to celebrate the opening of a new department dedicated to wastewater and to take the stock of the research and innovation activities carried out over these past ten years: 120 projects concluded, 70 researchers (7 of which hired with full time contracts), 140 employees involved, 15 academic and 41 industrial partners, 2 Research and Innovation TOP Utility Awards (the first time in 2012 and the second in 2018), more than 50 scientific publications.

These results allow us to look forward with greater awareness, outlining even more ambitious priorities and objectives for the coming years.

Numerous are the challenges that we will be called to face: the necessity to preserve a vulnerable resource as water, which is at the heart of our daily effort, the promotion of a sustainable economic growth contributing to job creation, the acknowledgement of water value within a circular economy, the source control of pollutants, with special attention to emerging micropollutants such as micro and nanoplastics, the growing impact of climate change, the increased efficiency in the water service sector, the guarantee of resilience towards security risks and much more.

The international community is supporting us in these purposes: the United Nations 2030 Agenda for Sustainable Development, subscribed in 2015 by 193 member states, consists of 17 objectives, articulated in 169 specific targets, with the ultimate purpose to shape a sustainable development model under an economic, social and environmental point of view. Some of the most significant objective are worth to mention: achieve universal and equitable access to safe drinking water for all; improve water quality by reducing pollution, eliminating uncontrolled discharge and minimizing the release of dangerous chemicals and material; reduce the percentage of untreated wastewater and increase recycling and reuse.

Many of our research projects are in line with these objectives, as pointed out in the descriptive sheets by special ‘sustainable development goals’ icons.

SMAT Research Center is proud of the job done during these past ten years and, above all, we are confident to have laid the foundations for a continuous improvement.

Research Center Director
Lorenza Meucci

President
Paolo Romano

February 2019

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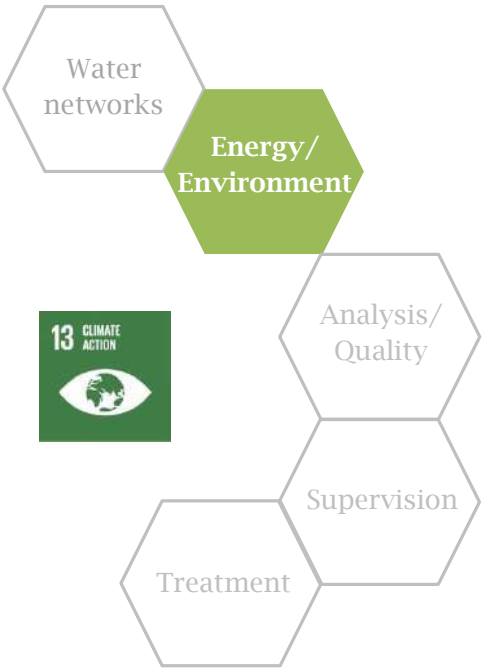
Projects closed in 2018

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 goal of this research project was the assessment of vulnerability to climate change effects for groundwater resources intended for human consumption in the Turin area. This vulnerability will be explored both in quantitative (water availability) and qualitative (maintaining of physical and chemical characteristics) terms, forecasting its trend up to 2050.
Quantitative estimation of aquifer recharge in climate change scenarios was obtained considering the following forecasting chain:

- 5 global climate models (GCMs) which provide climate scenarios for the entire planet (temperature and precipitation fields);
- 1 regional climate model (RCM) nested into global models;
- a hydrological model forced with these high-resolution climatic inputs to simulate the hydrological response and water balance terms at the scale of interest.

Climate projections suggested a "stationary" trend of groundwater availability at yearly timescale. Seasonal projections show a potentially critical situation on the second half of the year, especially on the fourth quarter, with a decreasing trend of groundwater availability. Climate scenarios indicate high interannual precipitation variability as the main issue that SMAT will be facing on its territory.

Geochemical characterization of the aquifers was carried out in order to estimate qualitative groundwater status, water-rock interactions and anthropogenic impact. Relationships between the main dissolved ions allowed to recognize two main components that contribute to determine the composition of groundwater, one of natural origin and the other of anthropogenic origin (primarily related to agriculture). This component assumes greater importance on the southern part of the Metropolitan City of Turin, were statistically significant positive trends of chlorides and nitrates were founded.

As a follow-up, SMAT decided to fund a new research project for the development of a groundwater circulation model to dispose of an innovative wells management tool. This way, SMAT will be able to optimally safeguard groundwater quality stability over time, by designing the likely pollutant pathways.

STATUS
Closed

STARTING DATE
August 2016

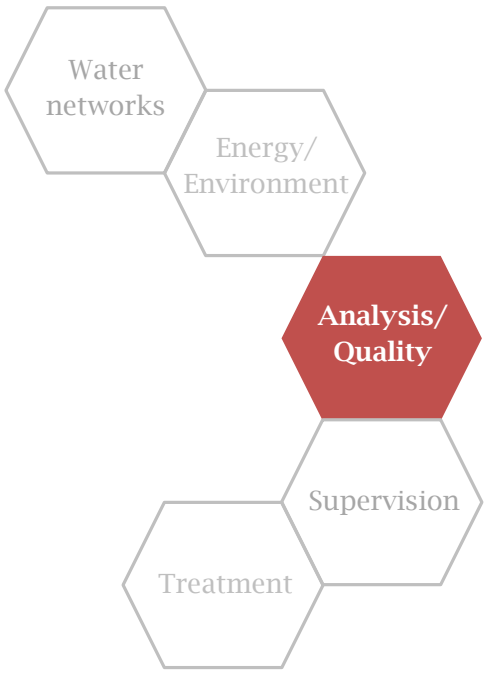
DURATION
30 months

FUNDING
No

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

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

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 and more reliable, rapid, efficient and safe methods for preventing, monitoring and controlling potential biocontaminations within human confined environments. To this aim and as a recognized expert in all steps of drinking water management as well as in water production for the International Space Station (ISS), SMAT and a group of international partners obtained from the European Union funding for a project 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 third and last year of work, SMAT supported the tests foreseen on the prevention module (a silver-containing tank, with antimicrobial properties) and coordinated the field tests in the Grotta del Vento cave (LU) and in the Research Center laboratories. Thanks to the comparison with traditional and next-generation analytical methods, the system demonstrated an excellent degree of sensitivity even on lowly contaminated water samples. The set of tests performed in the cave, representative of some aspects of a humanized and confined space habitat characterized by extreme environmental factors, proved its applicability even in a sub-optimal operational setting. Finally, SMAT drafted a market analysis on the prototype, highlighting its potential at the single module level and suggesting the desirable modifications needed for its commercial exploitation as an integrated system for Earth-related applications (such as hospitals and water distribution networks.).

STATUS
Closed

STARTING DATE
January 2016

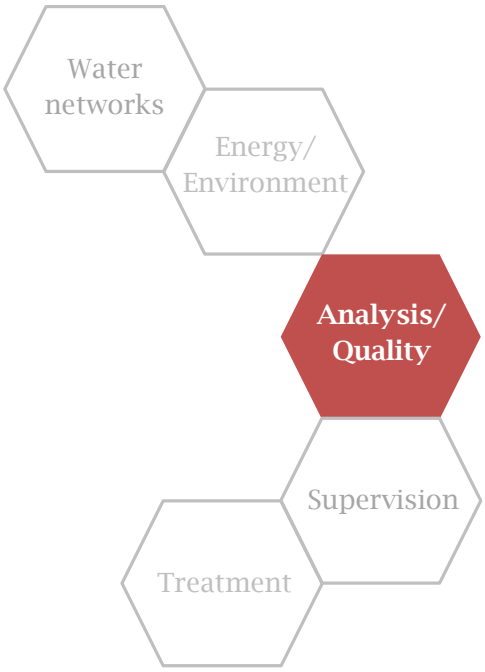
DURATION
36 months

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"

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 within the sample. The read and the update occur at approximately ten minutes intervals, issuing an almost instantaneous information about water quality.

The objective of the second phase of the project was the system validation within the context of real or simulated contaminations of distributed water and the investigation of potential field applications (in a water treatment plant or in a water kiosk). Once an alarm threshold was correctly defined for each specific water type, the system was able to effectively detect with high sensitivity water quality changes following beyond the threshold, demonstrating its applicability in monitoring the various treatment steps within a drinking water treatment plant. Nevertheless, the instrument was unable to accurately discriminate between chemical/physical and microbiological contamination events, thus suggesting the need of a deeper investigation in case of alarm. The overall overestimation of the microbial load and the comparison with other analytical techniques, indicative of microbial viability, highlighted the limits of the instrument in distinguishing live (active) and dead (inactive) organisms. Finally, the observation of a strong effect of pressure variations, linked to the normal operations of water kiosks, on read fluctuations discouraged its employment as an online analyzer in such settings.

STATUS
Closed

STARTING DATE
May 2017

DURATION
12 months

FUNDING
No

PARTNERS
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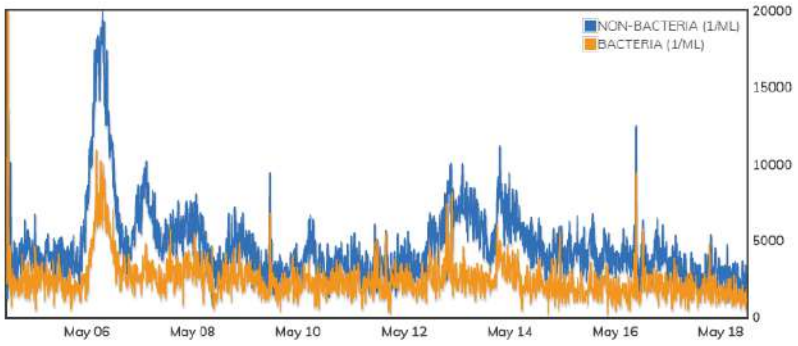
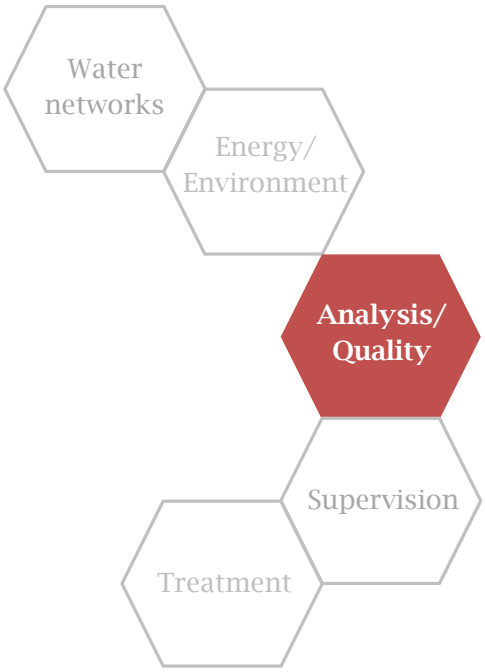


"The objective of the second phase of the project was the system validation within the context of real or simulated contaminations of distributed water and the investigation of potential field applications"

PERSEO - PERSONAL RADIATION SHIELDING FOR INTERPLANETARY MISSIONS



Radiation hazard to crews 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. Therefore, future long term missions require the definition of appropriate personal protection strategies to ensure adequate security conditions for astronauts' work.

The goal of 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. SMAT collaborated to the system's creation by designing and building of water bags contained inside the garment that constitute the shielding part. The shielding device was tested by the astronaut Paolo Nespoli on the International Space Station on 7th November 2017. During the in-orbit experimental session, the crew evaluated wearability-related aspects, as well as the simplicity of filling and discharging water bags.

Furthermore, water shielding properties were tested using an ALTEA/LIDAL detector, available on the International Space Station (ISS), on a test bag filled with flight water supplied by SMAT and delivered to the ISS.

Water contained on this bag was analyzed by SMAT laboratories at the end of the space mission. No pathogenic microorganisms contamination nor TOC threshold exceedance were found.

STATUS
Ongoing

STARTING DATE
January 2016

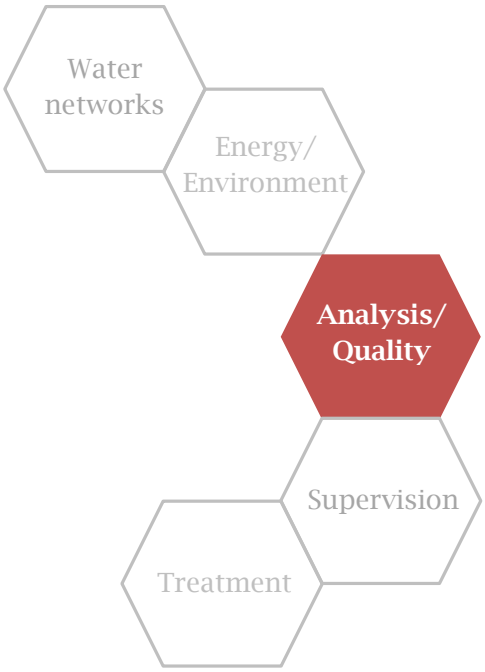
DURATION
36 months

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 PERSEO project is to study and develop innovative wearable radiation protection systems to mitigate the effects of cosmic radiation"

IMPROVEMENT OF WATER QUALITY IN SMAT WATER KIOSKS



SMAT manages about 200 water kiosks to supply refrigerated and sparkling water to users' communities. The occasional presence of *Pseudomonas aeruginosa* in samples collected from the faucets of some kiosk (even in absence of contamination of the distribution network) required some in-depth analysis: the bacterium showed high resistance to standard disinfection procedures and, even in case of initially effective disinfection, it reappeared after few weeks. Therefore, in March 2017 SMAT started a research project aimed at implementing extensive test activities in order to identify and remove contamination causes.

The project is articulated around four main axis: i- optimization of the disinfection procedure through testing alternative disinfectants, varying disinfection conditions (contact time, temperature) and testing innovative disinfection techniques (e.g. vacuum conditions); ii- plant structural analysis in order to identify possible risk factors (stagnation areas, materials in contact, pipes diameters in relation to time and frequency of periodic flushing; iii- testing of integrative disinfection systems (ultra-filtration, UV sterilization); iv- review of operational procedures for the plant's management from installation to start-up.

The study revealed the ineffectiveness of disinfection procedures tested on biofilm responsible for the presence of the bacterium in the collected samples. At the same time, it allowed to identify solutions to avoid its formation in the first place.

STATUS
Closed

STARTING DATE
November 2012

DURATION
60 months

FUNDING
No

PARTNERS
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"The study allowed to identify solutions to prevent the formation of biofilm, which could be responsible for contamination from Pseudomonas aeruginosa and highly resistant to disinfection."

DECISION SUPPORT SYSTEM FOR A PIPE NETWORK REPLACEMENT PROGRAM

Water networks

Energy/ Environment

Analysis/ Quality

Supervision

Treatment

The project aims to develop a tool that optimizes the economic resources to be allocated to the maintenance of water distribution networks. Decisions concerning pipelines replacement priority will be based on objective criteria: statistical analysis of breakdown probability, cost of replacement and importance of the pipeline section from the hydraulic point of view.

Breakdown causes are multiple. Besides the conditions to which the pipe is subject, some breakdown factors are typical of a certain class of materials. In addition to purely chemical phenomena, the stress source can often be a phenomenon called pressure transients, which is still rarely measured in water distribution networks. Pressure transients, 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 sources. For example, pressure levels, but also heavy vehicles traffic density that insists over the pipelines.

The tool that will be developed, in addition to optimally addressing the economic resources allocated to pipelines maintenance, 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
Closed

STARTING DATE
January 2018

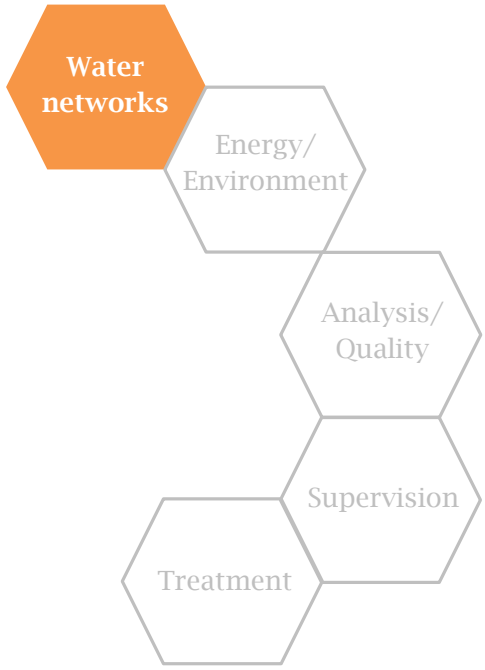
DURATION
12 Months

FUNDING
No

PARTNERS
HERA, IREN

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

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 pipe materials is a common event. Substances that can be found on the internal pipe surface (biofilm) represents a fertile soil for microorganisms. 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, with a strictly scientific on-field approach.

Among the tested technologies, best results is based were obtained with a simple mixture of water, salt and ice, which is introduced and slid into the pipe to be cleaned. This mixture has the ability to detach the deposits accumulated over the years from the pipes walls and transport it to the point of exit.

In order to test this technology two pilot plants were developed. The first, with a capacity of 80 liters, allowed to carry out the first laboratory experiments. The second, with a capacity of 700 liters, represented the first application of this technology at real scale, even if for short traits. The positive results obtained, led to further development of the project up to the construction of a cleaning plant that has already been adopted by the company, for an extensive pipes cleaning campaign. The system, with a capacity of 4 m^3 is capable of cleaning pipeline sections up to 1 km long.

STATUS
Closed

STARTING DATE
January 2016

DURATION
36 Months

FUNDING
No

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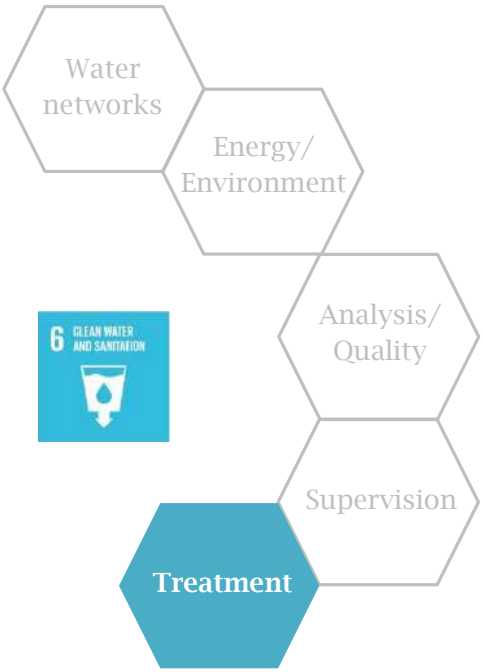
"The aim of this project is to verify the efficacy of some innovative cleaning technologies for hydraulic pipelines, validating their effectiveness with a strictly scientific on-field approach"

WATER DISINFECTION BY HYDRODINAMIC CAVITATION



Hydrodinamic cavitation is a physical-chemical phenomenon induced by a pressure variation obtained through a hydraulic system, determining the formation of a vapour (or vacuum) zone within a fluid. The generated microbubbles (or "cavities") implode upon a subsequent pressure increase, inducing a series of highly energetic phenomena. The reaction may be exploited in a positive way to prime chemical and mechanical processes with a wide range of potential applications. Of particular interest is the study of hydrodinamic cavitation applicability in drinking water disinfection using its principles to compromise microbial cell integrity and viability with a combination of physical and chemical-oxidative processes.

Building on a collaboration with the Polythecnic University of Turin that had led to the construction of a lab scale 20 liter capacity plant and to the collection of a number of preliminary data, the aim of the project was the evaluation of the efficacy of hydrodynamic cavitation and of the critical variables of the process in relation to microbial load reduction. The experimental protocol, from bacteria resuspension to treatment and downstream microbiological analysis, was developed to maintain high standards of robustness and reproducibility. Several tests were performed accordingly, with a tight control of uncertainties, allowing the isolation and identification of the effect of different variables (such as cavitation number and number of holes in the reactor). The system was able to determine a 70-80% abatement of the bacterial load upon a two-hour loop treatment, thus providing an excellent baseline for the optimization required for the process scale-up on real water treatment plants.

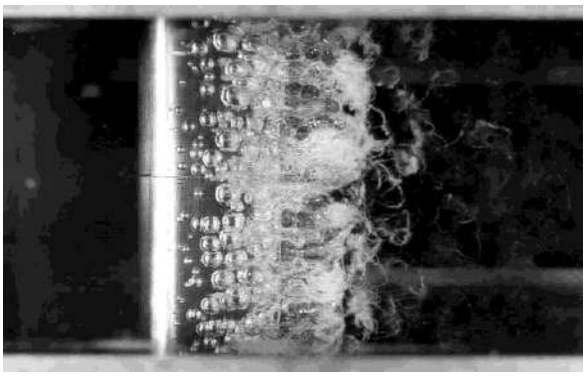
STATUS
Closed

STARTING DATE
December 2017

DURATION
12 months

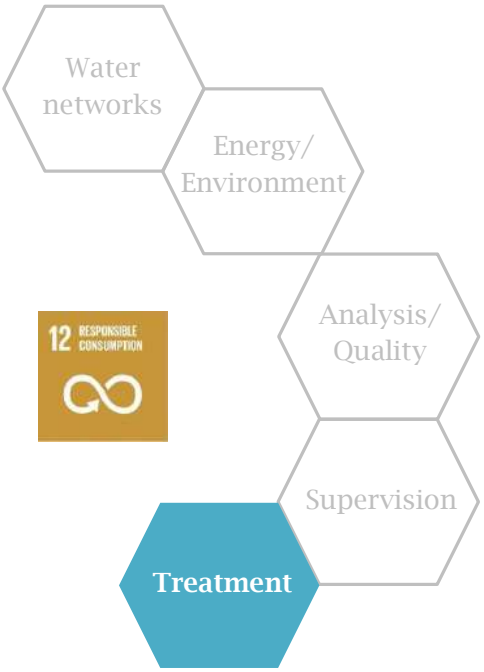
FUNDING
No

PARTNER
Polytechnic University of Turin



"The aim of the project was the evaluation of the efficacy of hydrodynamic cavitation and of the critical variables of the process in relation to microbial load reduction"

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 contaminants removal performances, the possibility to consider wastewater as a resource rather than a waste product. From this point of view, several technologies have been developed for water reuse, for electrical and thermal energy recovery through biogas production from sewage sludge and for sewage sludge reuse (for agricultural or cement production).

An even more forward-looking approach and a further step along this way is represented by the recovery raw materials to be re-used as common commercial products with economic and environmental advantages. Several efforts have been deployed towards this goal and, at present, one of the most promising applications is phosphorus and nitrogen recovery through the production of struvite (a salt composed by phosphorus, 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 fertilizers, is a fundamental theme from an environmental point of view.

During this project we evaluated, in collaboration with HERA, IREN, Polytechnic University of Turin, Polytechnic University of Marche and University of Trento, the technical and economic feasibility of struvite recovery technologies introduction in some of the wastewater treatment plants managed by the three utilities involved in the project partnership. SMAT focused on Castiglione T.se wastewater treatment plant.

Several commercially available technologies were evaluated and compared based on production yields, operating and capital costs and compatibility with existing processes and plants.

Finally, we prepared a preliminary design of the system and defined the conditions to be met for the real scale application.

These evaluations, as soon as regulatory and market conditions will be favorable, will allow the utilities to implement the upgrade of installations for struvite recovery.

STATUS
Closed

STARTING DATE
June 2017

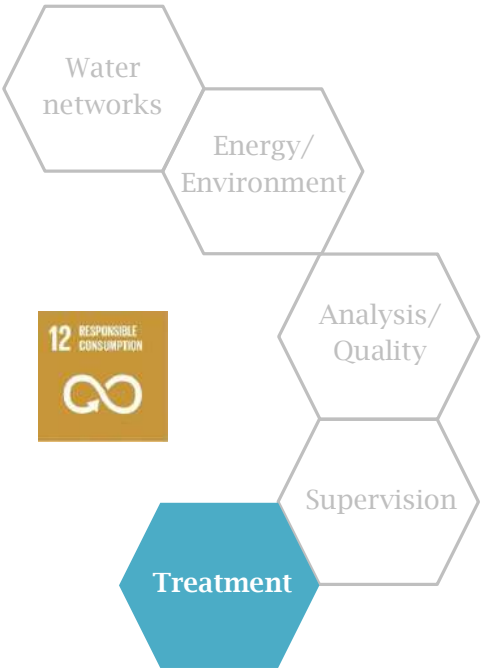
DURATION
18 months

FUNDING
No

PARTNERS
HERA, IREN, Polytechnic University of Turin, Polytechnic University of Marche, University of Trento

"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"

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 removal through low cost biochar.

During the first phase, the project focused on the definition and setup of the analytical method for the detection of nine HAA chlorine- and bromine-derived congeners and the emerging compound MIAA in presence of bromate. The method is based on ion chromatography coupled with triple quadrupole mass spectrometry (IC-MS/MS). This phase was concluded by an extensive analysis campaign on water samples from the distribution network managed by SMAT. Measurements confirmed the low HAA content, which was found to be well below the limits set in the European Directive review proposal published in February 2018. The mentioned proposal introduces 5 HAA among the parametrical values to determine the quality of water for human consumption. The presence of HAA was detected especially in water treated with chlorine dioxide.
Subsequently, biochar was characterized in terms of metals and polycyclic aromatic hydrocarbon release in water, as well as chemical and physical parameters, in order to select the most suitable substrate towards the adsorption of target pollutants. Finally, different types of biochar were tested for HAA and pesticides removal performances in comparison with granular active carbon , currently in use.

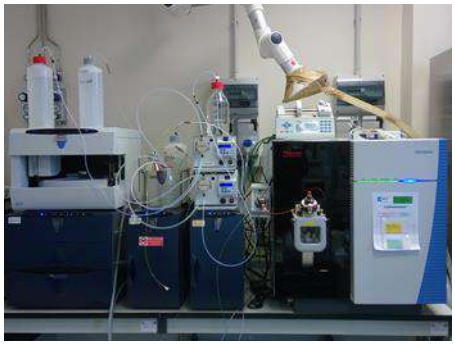
STATUS
Ongoing

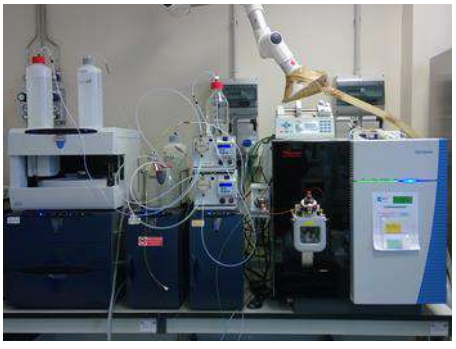
STARTING DATE
January 2017

DURATION
24 months

FUNDING
No

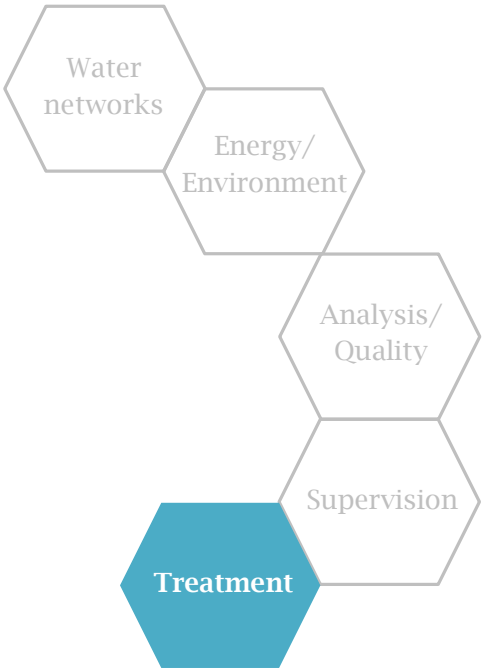
PARTNERS
University of Turin, Chemistry Department





"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.)"

EXCLUSION ZONE STUDY USING NUCLEAR MAGNETIC RESONANCE TECHNIQUES



The so-called "Exclusion Zone" (EZ) is 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. Although the scientific debate for explaining the mechanism responsible for the phenomenon is still open, the phenomenon raises great scientific interest and could be of essential importance for separation and filtration technologies, water purification, fouling prevention and ion exchange chromatography. 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. By evaluating specific NMR spectroscopy parameters (T1, T2), such technologies allow to evaluate water molecules' mobility and to identify the forces acting on EZ formation.

Nafion was used as test material for EZ formation. MRI images show an area around the membrane where water molecules have less mobility compared to bulk water. This area was defined as Low Mobility Zone (LMZ), confirming the presence of partial water structuring.

The Low Mobility Zone depends on proton concentration and, up to a certain extent, not on dissolved salts concentration.

The aforementioned analysis, together with the performed comparisons with particles and dissolved ions exclusion experiments, allowed to understand that the Low Mobility Zone observed with MRI techniques and the EZ visible in microscope images coexist on Nafion surface. However, EZ and LMZ are determined by different forces. EZ "driving force" is mainly related to diffusion phenomena.

The results of this project showed that, through optimal functionalization, antifouling materials could be generated.

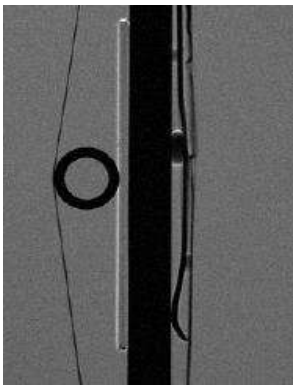
STATUS
Closed

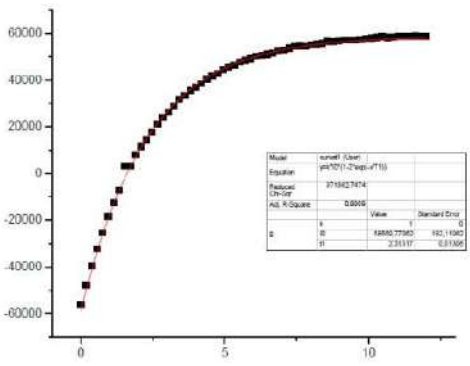
STARTING DATE
February 2017

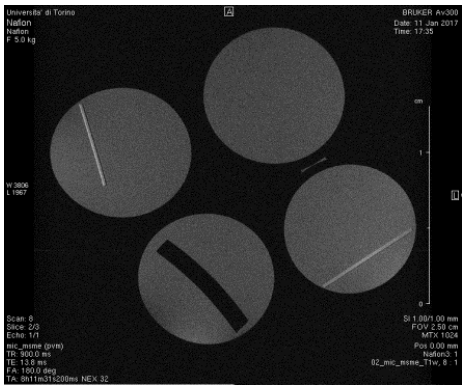
DURATION
24 months

FUNDING
No

PARTNERS
University of Turin

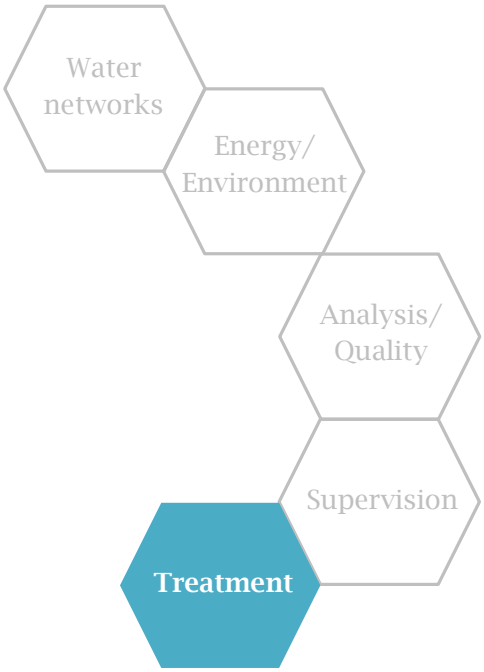






"The presence of an Exclusion Zone where water has less mobility than bulk water was confirmed by Nuclear Magnetic Resonance techniques"

ALGAEBIOUP



A valuable alternative to traditional biogas recovery through cogeneration of electric and thermal power is the so called biomethanation. It consists in a biogas purification process, through the removal of carbon dioxide and other impurities (i.e. sulphydric acid and siloxanes). Biomethanation is aimed at producing quasi-pure methane that, if the required quality standards are met, could be introduced into the natural gas distribution grid and used, for example, for transportation purposes.

During the project, an innovative biomethanation technology, based on microalgae cultivation in photobioreactors was studied and tested.
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, pre-treated biogas is the source of CO2 for algae. This process generates two products: 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 to select 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 evaluated algae production rates and biomethane purification capacity.
The experimental results at pilot scale showed excellent growing rates (algae biomass concentration up to 8 g/L were reached) and CO2 removal rates, and proved a possible future industrial application of the process.
In a future project it will be possible to study the system's behavior when fed with real biogas in an industrial environment, in order to achieve more precise evaluations about the feasibility of the process application at industrial scale.

STATUS
Closed

STARTING DATE
January 2016

DURATION
30 months

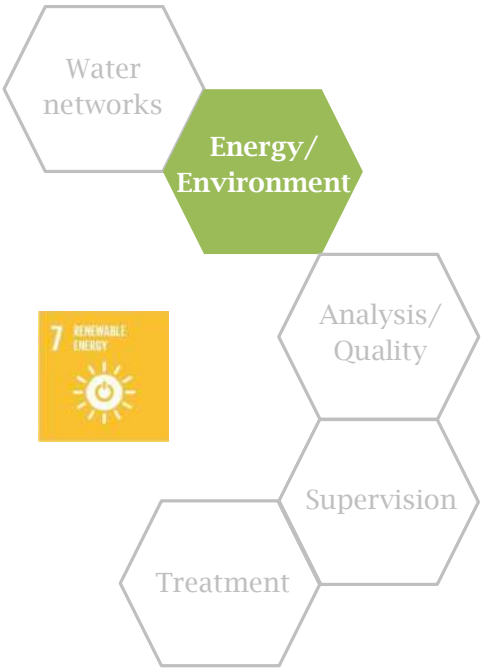
FUNDING
No

PARTNERS
Polytechnic University of Turin

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

Ongoing projects

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.

SOFCs are new generation cells, able to exploit biogas as fuel. Before being used 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 2018, the second 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

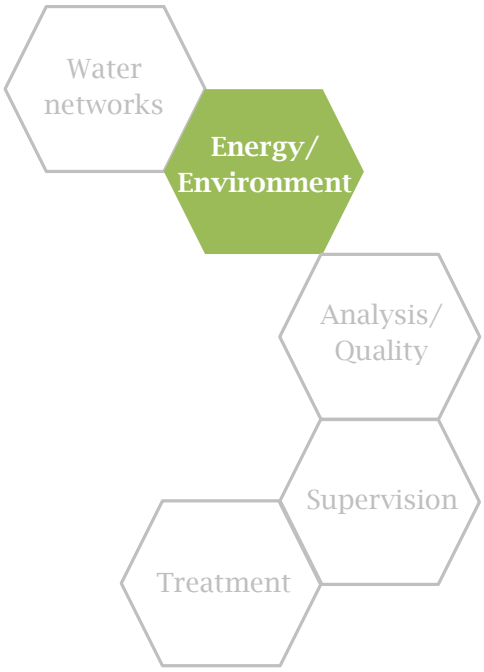
DURATION
60 months

FUNDING
Si

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

"The second 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"

BIOGAS4ENERGY



The production of biogas from anaerobic digestion of wastewater treatment sludges is an optimal example, from the circular economy perspective, of the transformation of waste into renewable energy resource.
Recent technological developments in the field of fuel cells allow the use of this energy resource with growing performance and efficiency, both from the energetic point of view (electrical efficiency >50%) and from atmospheric emission point of view.
A potentially critical issue in the application of biogas from sewage sludge to supply fuel cells (particularly Solid Oxide Fuel Cell), is the need of biogas pre-treatment in order to reach the almost complete removal of contaminants (mostly sulphur compounds and siloxanes) that might compromise fuel cells' performances and functionality.

Biogas4energy project, financed by Regione Piemonte as part of European Regional Development Fund, is focused on studying the purification and ultra-purification of biogas to be used in high efficiency fuel cells.

During the first part of the project activities consisted in experimental tests on several adsorbent materials in order to select the most suitable for biogas purification. After being lab-tested, the materials underwent a second test phase at the wastewater treatment plant in Collegno, where modules of SOFC fed with biogas were installed as part of European project DEMOSOFC. The purification system performances in terms of contaminants removal capacity and adsorbent bed duration were studied in a real scale application.

At the end of test phases a prototype reactor for biogas treatment will be developed. It will be based on an adsorbent material (biochar) produced by the activation of dried wastewater treatment sludge.

STATUS
Ongoing

STARTING DATE
October 2017

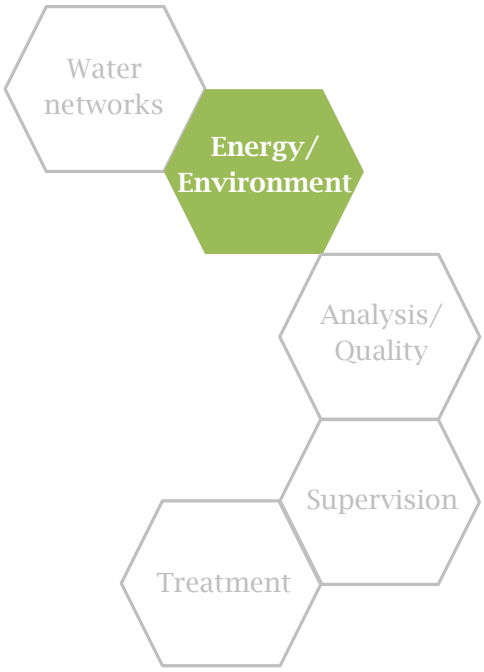
DURATION
24 months

FUNDING
Yes

PARTNERS
Hysytech, Politecnico di Torino

"The project is focused on studying the purification and ultra-purification of biogas for application in high efficiency fuel cells"

BIOMETHANE



Today, in Castiglione T.se wastewater treatment plant, biogas produced by the anaerobic digestion of sewage sludge is reused for cogeneration of renewable electrical and thermal energy.

Recent innovations in the Italian legislation opened, and strongly incentivized, a new possibility for biogas recovery: biomethanation is the process by which CO_2 and other contaminant compounds (H_2O, H_2S, siloxanes, halogen compounds, etc.) are removed from biogas in order to obtain a methane concentration almost equal to that of natural gas (usually >95%), suitable for its introduction into the distribution grid.

New Italian regulations provide for biomethane to substitute fossil natural gas in the transport sector. All biogas chemical energy (calorific value), currently used for auto-consumed electrical and thermal energy production, could be transferred to the transport system that will benefit from a renewable energy source.

STATUS
Ongoing

STARTING DATE
October 2018

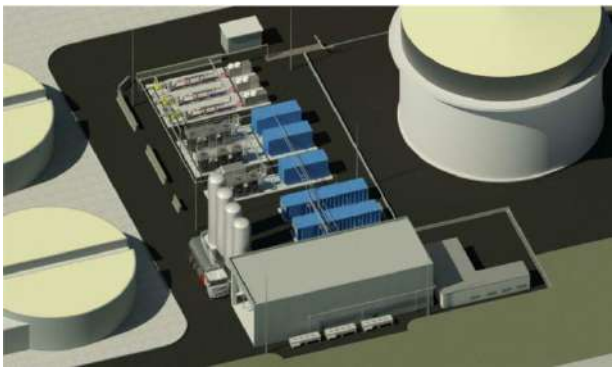
DURATION
18 months

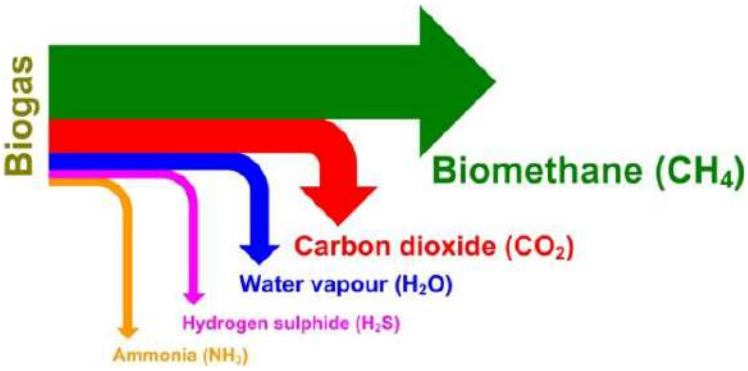
FUNDING
No

PARTNERS
//

The objective of this project is to study the technical and economic feasibility of a biogas up-grading technology for biomethane production and introduction into SNAM natural gas distribution grid.

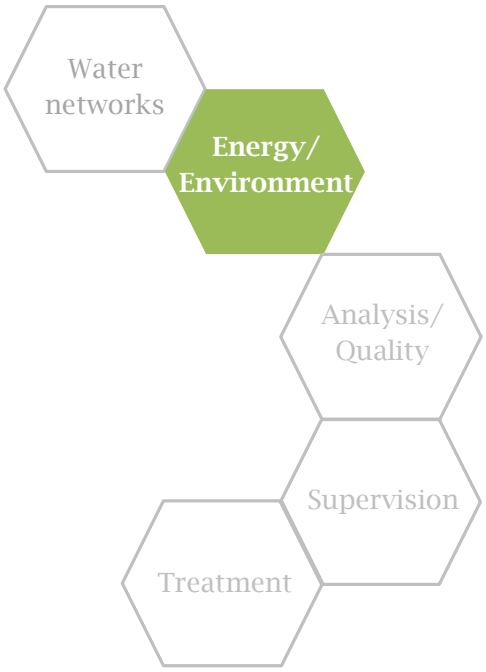
In particular, different biogas-use scenarios (among which also cogeneration, currently in use) are analysed. Scenarios are compared from economic and environmental points of view. Impacts from green-house gases perspective will be assessed through the calculation of CO_2 equivalent emissions and net savings. The possibility to introduce a plant section for biogas CO_2 recovery and liquefaction will also be considered.





"The objective of this project is to study the technical and economic feasibility of a biogas up-grading technology for biomethane production in Castiglione T.se wastewater treatment plant"

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 integrated monitoring system of odor impacts includes:

- installation of a station for continuous monitoring of local weather conditions;
- specific characterization, by means of appropriate measurement campaigns, of the chemical species and the emission sources that are mainly responsible of odor impacts;
- analysis, through joint measurements and subsequent elaborations, of the relationship between concentration of volatile chemical species and odor concentration measured onsite;
- development of a monitoring network for concentrations in air of the substances that are mainly responsible of odor impacts (VOCs, hydrogen sulphide and ammonia);
- development of a modelling chain integrating the measurements of the monitoring network and, based on the local meteorological conditions, simulating odor dispersion, in way to characterize the area eventually affected by odor emissions.

Currently, the meteorological monitoring station is in operation. The site characterization phase is nearing completion, as is the processing of data from inspections and measurement campaigns. This processing phase is preliminary to the design of the integrated monitoring and modelling system.

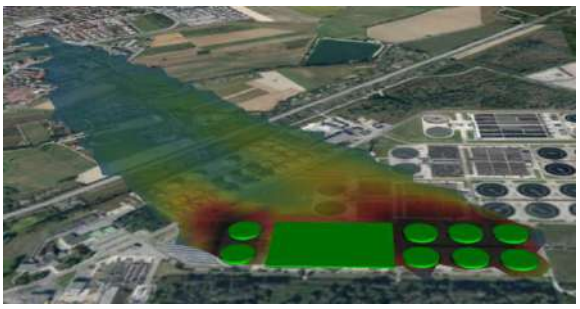
STATUS
Ongoing

STARTING DATE
March 2017

DURATION
24 months

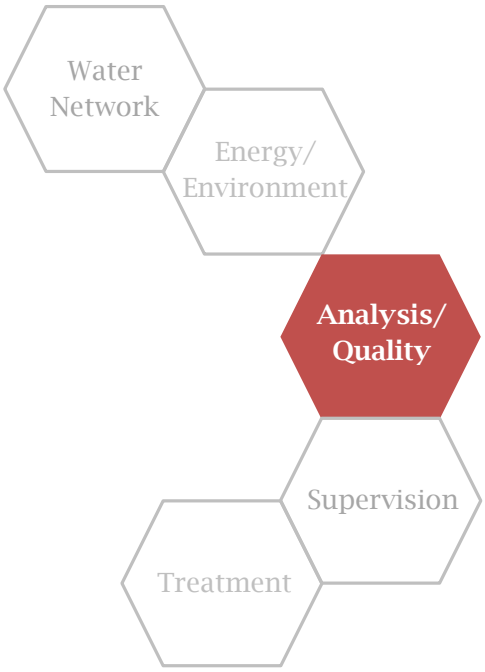
FUNDING
No

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



"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 "

DEVELOPMENT OF TURIN MUNICIPALITY WATER SAFETY PLAN



In 2016, SMAT Research Centre developed a tool to perform a homogeneous and guided risk assessment in order to draw up Water Safety Plans (WSP); subsequently the tool was tested and adapted on some "pilot" municipalities characterized by different plant equipment and morphological features.
In 2018, the Water Safety Plan for the city of Turin, whose distribution network supplies to about 900.000 inhabitants (almost half of the total population served by SMAT), was implemented.

The whole water system was subdivided into 9 areas, defined in such a way that each one constitutes a single water supply chain (from catchment to distribution) and further subdivided into sub-areas in case of more than one operational management.
New risk assessment checklists were developed because some catchments and treatments in Turin's water system were not taken into account in the tool developed in 2016.
Concerning the catchment, specific risk assessment checklists were created for the lagoon and the drainage tunnels.
In order to perform the risk assessment on Po river treatment plant, a specific checklist for the multistep treatment plant, that takes into account all the treatment's steps (pre-oxidation, clariflocculation, filtration, disinfection) was created.
Risk assessment results show, most of all, some medium-low risks, for which it is advisable (not a priority) to implement more effective control measures.
In order to complete the WSP, short, medium and long-term action plans will be proposed according to identified priorities.

STATUS
Ongoing

STARTING DATE
January 2018

DURATION
12 months

FUNDING
No

PARTNERS
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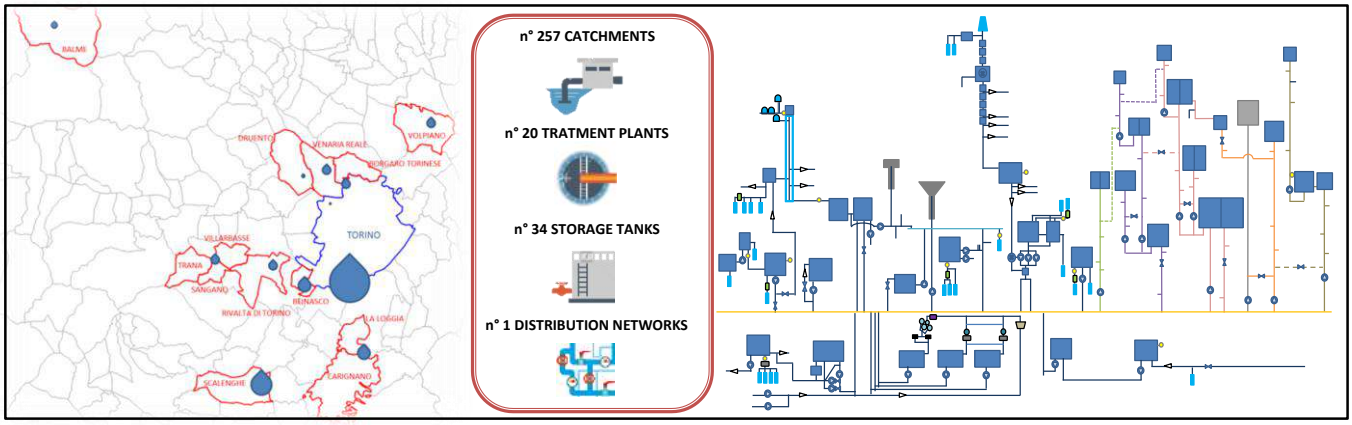
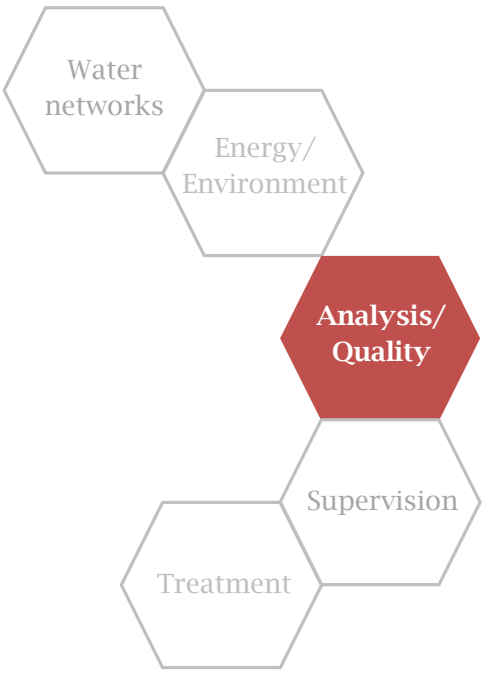


"The project consisted in the application of the tool developed by SMAT Research Centre for the implementation of Turin municipality Water Safety Plan ".

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 culture methods, whenever available, are not always species-specific, are usually long-term (days) and are not always straightforward to interpret. For these reasons, back in 2008, SMAT introduced PCR as a first attempt to apply fast and reliable biotechnological methods in parallel with traditional microbiology. Following the recent 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 can then undergo PCR to amplify selected genomic regions that allow identification of the microorganism with a higher degree of sensitivity and specificity than traditional methods. The application field includes virtually all microorganisms for which the genomic sequence is publicly available. In the early stages of the project, the first task consisted in a systematic comparison of multiple concentration, extraction and amplification methods to identify the best combination of techniques. The second step was the preliminary study of a procedure to discriminate live (thus potentially pathogenic) and dead cells to avoid false positive calls, especially in treated water samples. We further expanded the analytical options based on molecular methods thanks to the acquisition of a Digital PCR machine, a next-generation instrument for direct quantification of the target sequences of interest.

STATUS
Ongoing

STARTING DATE
December 2017

DURATION
24 months

FUNDING
No

PARTNERS
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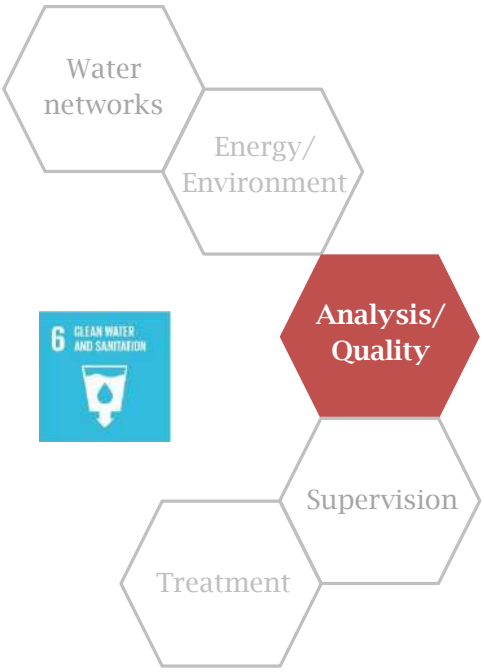
"The application field includes virtually all microorganisms for which the genomic sequence is publicly available"

ANALYSIS OF EMERGING POLLUTANTS 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. The list is regularly updated based on data being collected. Substances that are found harmful to the aquatic environment are taken into account by the specific sector's regulations. The proposed revised Drinking Water Directive sets very low limits for some of these substances, implying the necessity of very highly specialized equipment and personnel to perform the analysis.

In 2018, the separation technique (HPLC/MS/MS) optimization was completed and detection methods were validated for the following classes of pollutants:

Pesticides and their metabolites: in relation to the three most common active substances in the target territory (terbuthylazine., atrazine e metolachlor), we studied biological degradation pathways that might take place during water treatment processes (also in batch tests). These studies led to the identification of 13 metabolites that were analyzed in real samples, together with their precursors through nanograms sensitive measurement techniques. Results show values well below the already precautionary limits sets by law.

Perfluoroalkylated substances (PFAS): 17 compounds (including carboxylic and sulphonic acids) were identified based on literature. The developed method, in a "green chemistry" view, does not prescribe any sample-pre-treatment and chromatographic runs were shortened in order to reduce solvents' employment. The methods were applied for extensive monitoring campaigns across the area managed by SMAT and along potabilization processes for a total amount of about 1300 samples. Results did not show any significant criticality.

STATUS
Ongoing

STARTING DATE
January 2017

DURATION
30 months

FUNDING
No

PARTNERS
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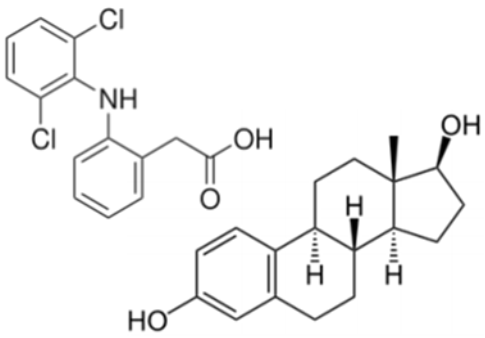
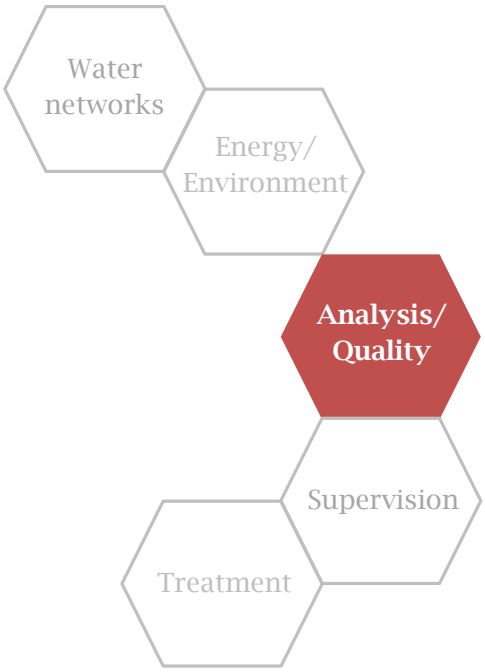


"The assessment of pollutants' spread always represents the first step towards the implementation of any containment measure"

MICROPLASTICS AND POTABLE WATER



Microplastics in drinking water: researchers from Fredonia University (USA) were the first who launched this alarm with a study published in 2017. The research showed that microplastics were detected in 83% of samples collected from home tabs in different cities around the world. The following year, the same team carried out a similar study on 259 bottled water samples from the most common brands around the world. Microplastics were found in 241 (93%) samples. The news, internationally spread by several media, raised great concern among consumers.

SMAT, together with other two industrial partners, Società A2A Ciclo Idrico and Società Metropolitana Milanese (both in charge for the integrated water service in Lombardy Region), decided to start a research project in 2018 in collaboration with Istituto Mario Negri and University of Milan. The project consist of the following activities:

- Creation of standards for the main polymers found in surface waters as microplastics (2 methods)
- Definition of two analytical methods for sampling, particles extraction and polymers counting with sufficient sensitivity (GC/MS techniques with TED and HPLC/MS-MS, IR with GCP and electronic microscopy SEM/EDX)
- Sampling and analysis of surface, treated and distributed water versus bottled water

The first two phases of the project were successfully concluded during the first semester. The third activity is currently ongoing.

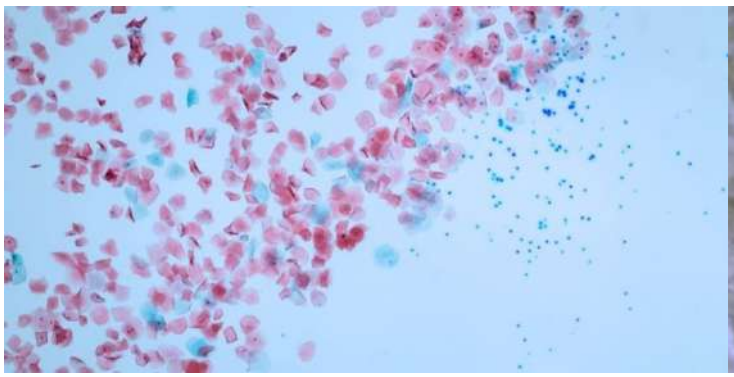
STATUS
Ongoing

STARTING DATE
July 2018

DURATION
12 months

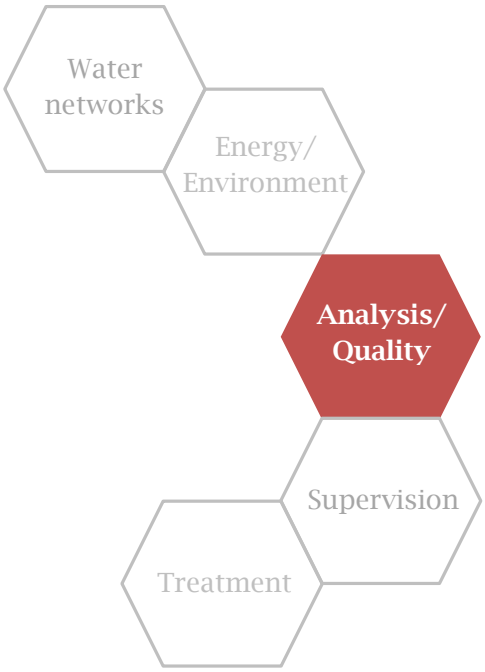
FUNDING
No

PARTNERS
A2A Ciclo Idrico, Metropolitana Milanese, Ist. Mario Negri, Università di Milano



"In 2017, researchers from Fredonia University (USA) published a study showing the presence of microplastics in 83% of drinking water samples"

COMPARATIVE STUDY ON SAMPLING AND CONCENTRATION TECHNIQUES FOR ENTEROVIRUSES DETECTION IN DRINKING WATER



Enteroviruses are ubiquitous and cause a great variety of diseases, sometimes particularly severe, like poliomyelitis, hepatitis, myocarditis, meningitis. However, most of the infections provoked by enteroviruses are asymptomatic, mainly in children, and this favours their spread in the environment. Important concentrations of enteroviruses can be detected in in treated water for human consumption, as well as in surface freshwater and in seawater. These viruses show high adaptability to environmental conditions and resistance to water treatment processes.

Law decree 31/2001 prescribes the complete absence of enteroviruses in drinking water. Virological analysis of drinking water is subject to a number of problems related to volumes to be analysed, methods to be applied in order to isolate and/or quantify viruses in the sample. Specific objective of this project is to compare different methods for samples collection and concentration.

After an initial literature review concerning sampling and analysis techniques, the following concentration methodologies were selected for the comparison: 1)electropositive membranes followed by secondary concentration; 2) tangent ultrafiltration. Moreover, an alternative innovative methodology will be considered. The operational phase of the project started with the acquisition of the necessary skills to handle adenoviruses (selected as surrogates of enteroviruses for safety reasons). Subsequently, suppliers for concentration equipment were selected. In November 2018, the equipment for tangent ultrafiltration was installed at DSSPP laboratories and personnel properly trained. Currently, tests on drinking water samples are being carried out in order to optimize flow and pressure technical parameters for adenoviruses detection.

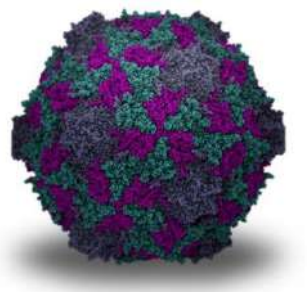
STATUS
Ongoing

STARTING DATE
September 2017

DURATION
18 months

FUNDING
Yes

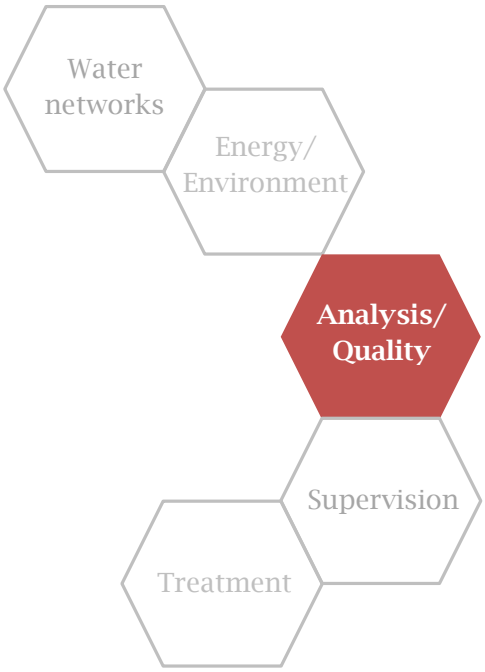
PARTNERS
Department of Public and Pediatric Health Sciences, University of Turin (DSSPP)



"The project's objective is to select the most sensitive and efficient technique to concentrate enteroviruses in different matrices of the integrated water cycle: surface freshwater, treated drinking water, wastewater treatment effluents".

Cod: LRC_AC_2017_13

ANTIBIOTIC RESISTANCE IN THE INTEGRATED WATER CYCLE



According to the World Health Organization, antibiotic resistance represents one of the main global public health issues of this century. Antibiotic Resistant Bacteria (ARB) have been detected in several water environments, while antibiotic resistance genes (ARG) can be transferred between different bacteria, from the human being to animals up to the natural environment and water resources. ARGs have been detected in a number of matrices, including sediments, lake, river and drinking water. These data demonstrate the key role played by urban water cycle in the diffusion of ARBs and ARGs.

In February 2018, SMAT started a project aimed at identifying and monitoring critical points in the integrated water cycle for the transferring and spreading of genes related to antibiotic resistance, also in relation to specific water treatment processes.

The first phase of the project mainly focused on an extensive literature review activity. Currently, sampling methodologies are being defined. The DSSP is also testing different methods for DNA extraction from matrices under investigation. During the second year antibiotic resistance will be measured in water samples from different treatment processes. Samples will be concentrated and the DNA extracted. Subsequently, qPCR will monitor and quantify the presence of resistance codifying sequences towards the most common antibiotic substances (genes *tet* for resistance to tetracycline, genes *sul* for sulfonamides). Antibiotic resistance rate will also be evaluated in microbial flora.

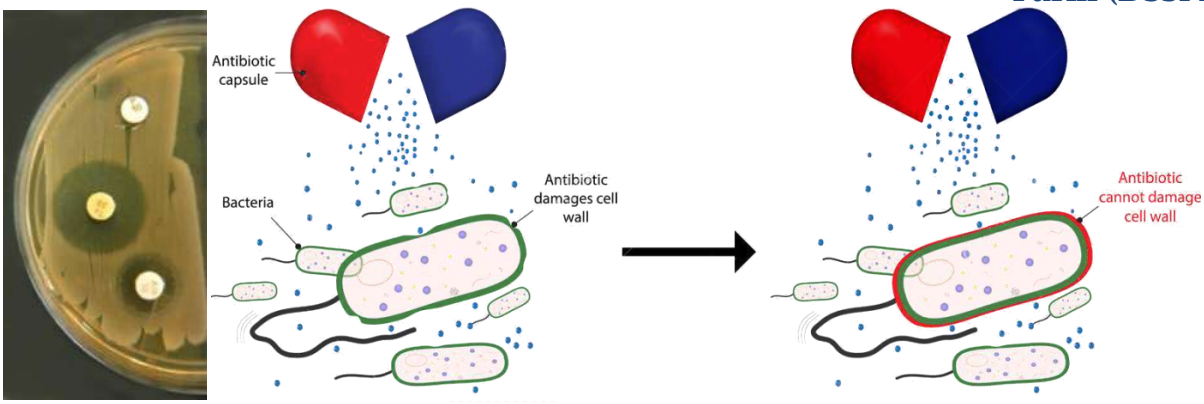
STATUS
Ongoing

STARTING DATE
February 2018

DURATION
30 months

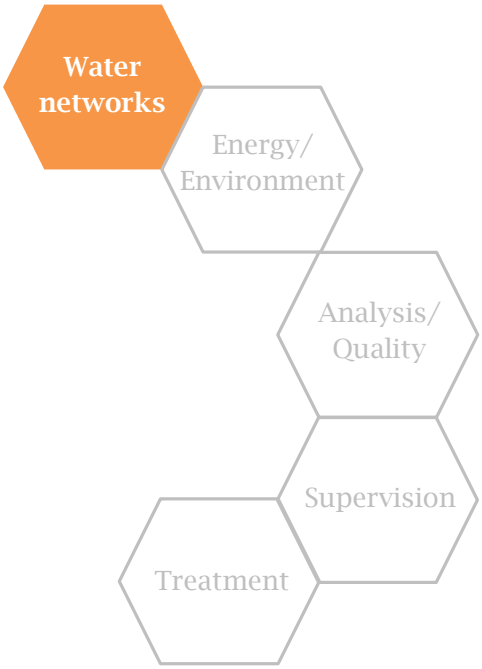
FUNDING
Yes

PARTNERS
Department of Public and Pediatric Health Sciences, University of Turin (DSSPP)



"Water is one of the principal habitats and propagation medium for bacteria playing a key role in spreading antibiotic resistance in the environment, among animals and human beings"

X-BAND SATELLITE SAR DATA ANALYSIS FOR LEAKAGE DETECTION



The research activity is devoted to X-band SAR (Synthetic Aperture Radar) satellite data acquisition and analysis for water leakage detection in the municipality of Turin. If possible, data from Cosmo SkyMed satellite constellation, owned by the Italian Space Agency, will also be used.
SAR data can be acquired both night and day, independently from cloud coverage, thus allowing a 24/24 monitoring on water networks: this represents a great advantage for water utilities that wants to detect water leakages as quickly as possible. Secondly, and most importantly, SAR images can be analyzed to monitor changes on land surface over time. Water utilities can exploit this information to assess soil changes in the proximity of water distribution networks and determine if soil moisture local are caused by water leakages from the network.

The research activity will result of in thematic maps showing soil moisture content, which can be considered as an indicator of possible water leakages from water networks. Thematic maps will be created in 4 areas containing a total of about 400 km of water pipes. By overlapping thematic maps with water network maps, it will be possible to precisely locate water leakages. Algorithm and process validation will allow to generate a continuous and systematic workflow for water leakage detection in the water network. The same activity will be carried out also in Verona, as the local water utility, Acque Veronesi, is a project partner.

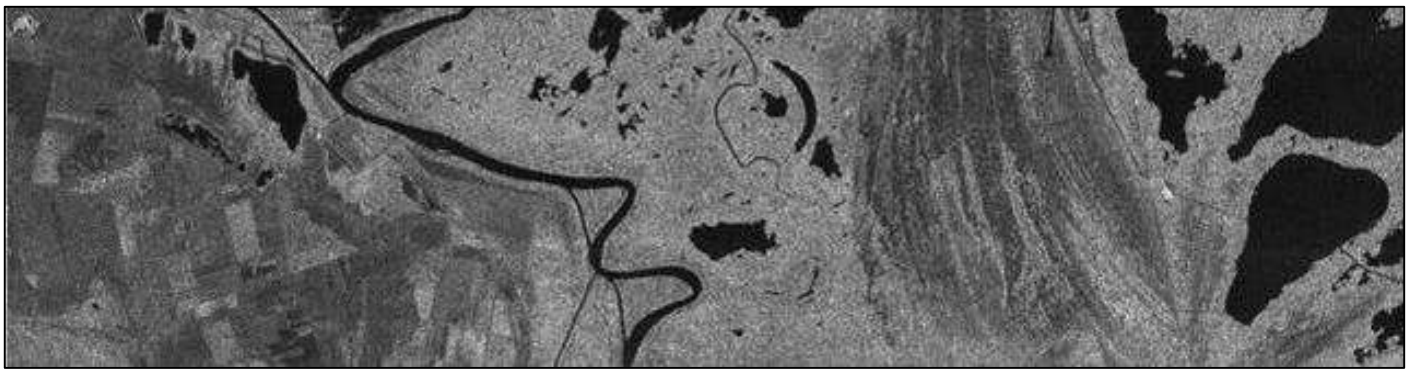
STATUS
Ongoing

STARTING DATE
December 2018

DURATION
7 months

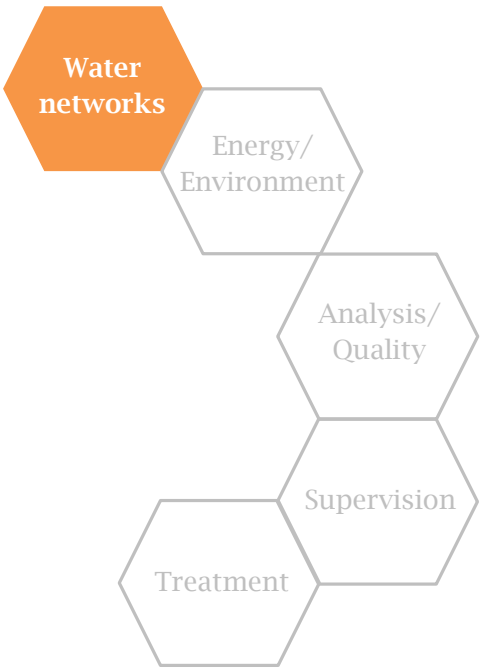
FUNDING
No

PARTNERS
Polytechnic University of Turin, Acque Veronesi



"The result of the research activities will be the production of thematic maps with soil moisture content in the terrain, that can be used as an indicator of leakages from the water network "

EXTENSION OF TURIN WATERSCHEME'S MATHEMATICAL MODEL TO CONNECTED MUNICIPALITIES IN THE HILLY AREA AND MODEL EXPLOITATION FOR FINALIZED APPLICATIONS



The project has a double objective. The first aim is to extend the mathematical model of Turin water scheme (built and calibrated within a previous project) to neighbor municipalities in the hilly area, which are connected to the same network. The second objective is to exploit the model for operational applications, for example the assessment and possible amendment of network development projects.
Mathematical modelling is acknowledged, both by academics and technology providers, to be an essential tool towards the accurate evaluation of parameters describing the dynamic of pressures and flow rates within a water system.

One of the applications of the existing model will be the verification of the distribution network districtualization project. Districtualization means division of the distribution network into sub-networks, where flow rates and pressures are permanently measured. Since this activity involves substantial changes to the topology of the networks, it is necessary to verify in a detailed and precise way that these variations do not negatively affect working pressure and water quality.

Another application concerns the optimization of energy consumptions from pumping stations. The amount of energy required to sustain the necessary pressure level can be significantly reduced, for example by modifying the start / stop moments of the various machines or by prioritizing the use of a certain plant over another, based on appropriate criteria

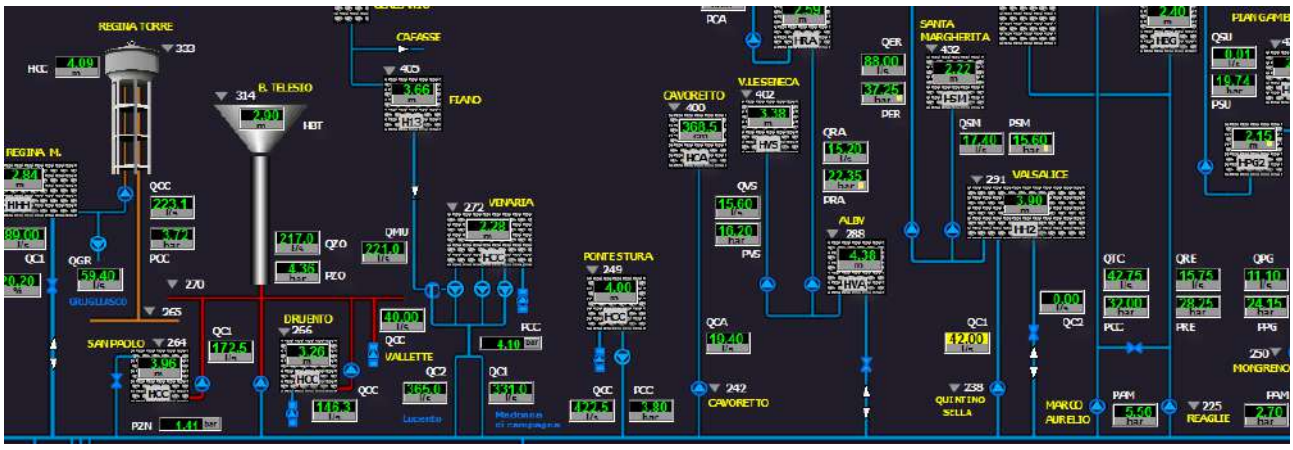
STATUS
Ongoing

STARTING DATE
June 2018

DURATION
24 months

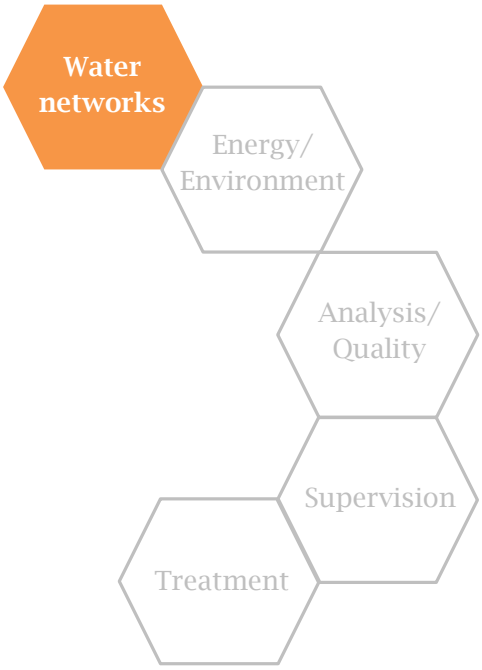
FUNDING
No

PARTNERS
Polytechnic University of Turin



"Mathematical modelling is acknowledged, both by academics and technology providers, to be an essential tool towards the accurate evaluation of parameters describing the dynamic of pressures and flow rates within a water scheme."

DESIGN AND IMPLEMENTATION OF DISTRICT METERED AREAS IN TURIN WATER DISTRIBUTION NETWORK



The project's objective is to implement the guidelines developed by the International Water Association (IWA) and recently adopted by the European Commission through the document titled "EU Reference document Good Practices on Leakage Management WFD CIS WG PoM" in the management of Turin water distribution network. The guidelines describe in detail practices aimed at implementing measured districts, in order to identify areas characterized by high leakages levels, increase interventions promptness in case of failures and prioritize breaks localization activities.

Each district will be treated as an independent and autonomous element, according to a series of work phases that include: (i) pre-analysis of the available information, for example the number of repairs or reported of failures, (ii) project for losses reduction and, in general, for a rationalization in the distribution network management, based on mathematical modeling, (iii) on-site activities for the project implementation, (iv) setting up of measurement points so as to keep track of the transited volumes and activate alarms in case of anomalies in pressure and flow rate values.

STATUS
Ongoing

STARTING DATE
January 2018

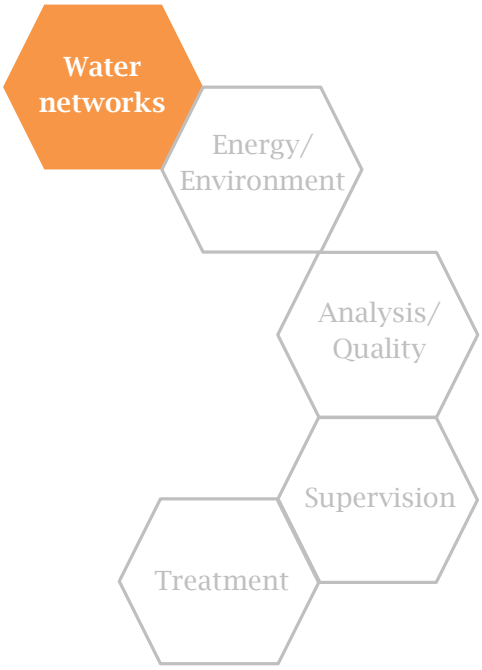
DURATION
36 months

FUNDING
No

PARTNERS
\\

"This project aims to identify areas characterized by high leakages levels, increase interventions promptness in case of failures and prioritize breaks localization activities."

STUDY AND DESIGN OF A METHODOLOGY FOR RESEARCH OF FAILURES ALONG THE SUSA VALLEY WATER SYSTEM



The new Susa Valley Water System shows some peculiarities that make it an extremely complex waterscheme: considerable length, strong differences in altitude, small reservoirs, numerous interfaces with local water systems. In addition to this, the main pipeline results to be subject to considerable hydraulic head. For this reason SMAT decided to explore the best available technologies in order to promptly report failures along the pipeline.

This problem, both from a technical and a scientific point of view, is still under debate today as proven by the number of research groups dedicated to the identification of a suitable solution all over the world.

The project is divided into three work phases.

During the first phase, the project focused on a detailed analysis of the pipeline characteristics (e.g. laying conditions, pressure levels, etc.). At the same time, an extensive literature review allowed a comparative study of available techniques, highlighting pros and cons of the different solutions. Secondly, the verification system was designed, based on the outcomes of the preliminary study. Following the design choice, mathematical simulations allowed the detailed definition of the verification system 's technical specifications.

In the coming months, once the pipeline is made operational and the devices envisaged in phase II are installed, a system validation procedure will be launched in order to make it robust, reliable and fully automated through its integration with the company's remote control platform.

STATUS
Ongoing

STARTING DATE
June 2018

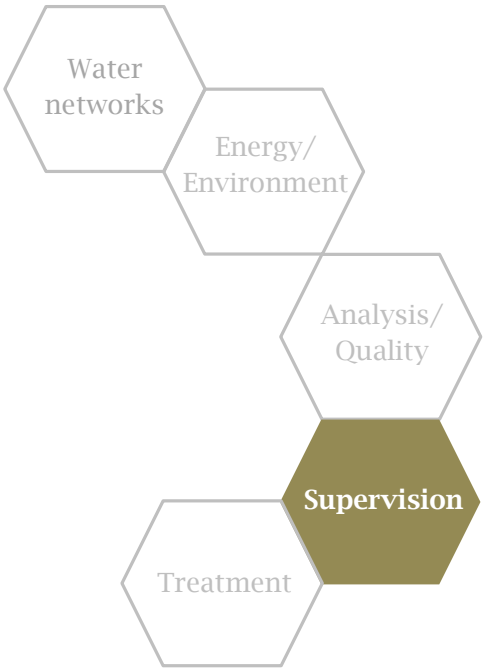
DURATION
12 months

FUNDING
No

PARTNERS
Polytechnic University of Turin, University of Perugia

"the Company has decided to explore the best technologies in order to prepare a system capable of highlighting failures along the pipe in time."

OPEN SOURCE PLATFORM FOR THE INTEGRATION, ANALYSIS AND PUBLICATION WATER DATA



Octopus wants to be the highest layer of a 4.0 SCADA system. In fact, in the current concept, the scheme of a normal SCADA includes: in-field infrastructure (sensors, PLC, RTU), communication (radio links, GSM, GPRS, etc.) and control room. Octopus would represent the highest layer of the system, with the purpose to transform the continuously incoming data into valuable information. Today, data are used by the control center for real-time operations and subsequently stored and "forgot" in databases.

One of the 4.0 revolution paradigms foresees the exploitation of all available data and their correlation with data from different sources, in order to generate new information to support objective and evidence-based decision-making.

Octopus will contribute to: analysis, forecasting and detection of anomalies in time series; analysis of ordinary and extraordinary maintenance data on infrastructure interventions; analysis of distribution networks water balance or energy consumption at plant scale, in order support plants and distribution networks management and to increase processes' safety and efficiency.

At full capacity, Octopus will act as a true tailor-made intelligent operator, built to be interfaced with all company databases and to grow according to new emerging needs. Being entirely based on open source software, Octopus does not imply license costs.

STATUS
Ongoing

STARTING DATE
October 2018

DURATION
12 months

FUNDING
No

PARTNERS
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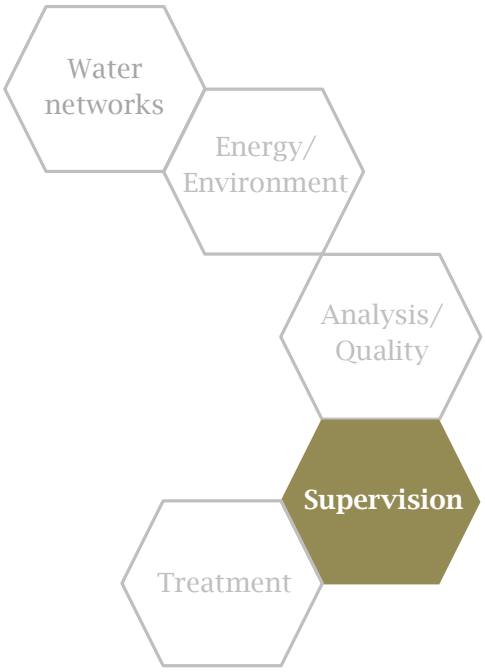
"Octopus at full capacity will be a true intelligent operator, interfaced with all company databases, that could grow according to the needs and needs that may arise"

DEVELOPMENT OF AN EARLY WARNING SYSTEM FOR THE CITIES OF TURIN AND RIVOLI BASED ON REAL-TIME SENSORS SUPPORTED BY MATHEMATICAL MODELING



The project is composed of three parts that will cooperate and interact in the construction of an "early warning" system able to automatically detect anomalies in the quality of the water supplied. A first part concerns measures on the water network. It is planned to install water quality meters in all the entry points of the Turin water distribution system and in all the water kiosks on the network. These meters will detect temperature, pH, chlorine concentration, oxygen, redox potential, conductivity and turbidity. The measurements will be transmitted real-time to the SCADA system (continuous measurement). The measurements will then be automatically compared with historical data from lab analyzes, so as to evaluate any significant deviation.

The second part will cover two different activities: measurements analysis and water quality mathematical modeling. The first of these involves the spatial and temporal analysis of measured time series, with the purpose extract as much information as possible from the measurements, using both classical techniques and innovative methods. The second activity concerns mathematical modeling of the measured quantities on the entire network. The comparison between measurements on the network and data provided by the model will make the system more sensitive, robust and reliable.

Finally, the alert system will be connected with the SCADA system, in order to manage alarms generated in compliance with management rules currently in use.

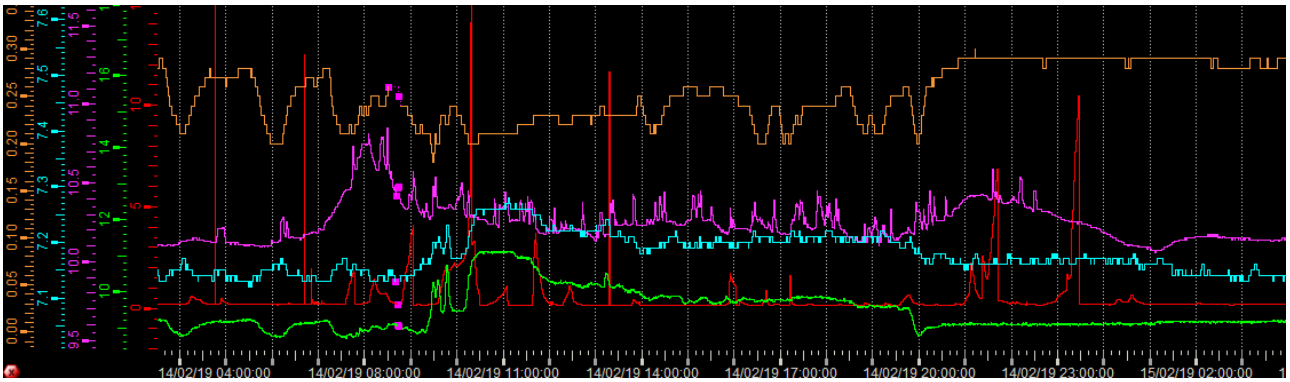
STATUS
Ongoing

STARTING DATE
June 2018

DURATION
24 months

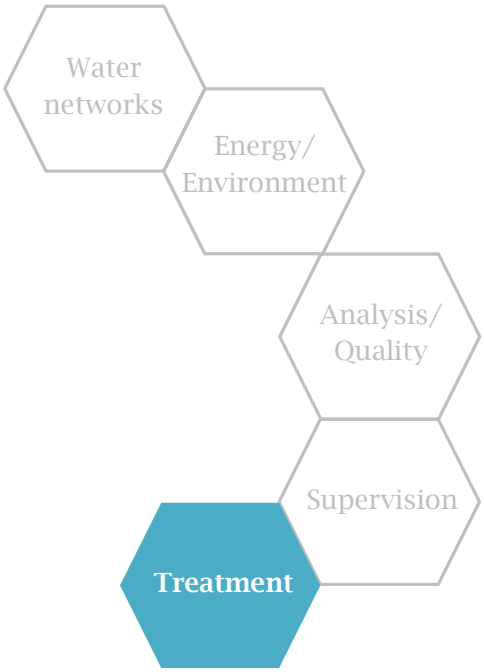
FUNDING
No

PARTNERS
Polytechnic University of Turin



"The project is composed of three parts that will cooperate and interact in the construction of an "early warning" system able to automatically detect anomalies in the quality of the water supplied"

INNOVATION IN WASTEWATER TREATMENT PROCESSES



The project, implemented in collaboration with the Plant Management Service and the Chemical-Biological Laboratory of Castiglione T.se wastewater treatment plant, will study and test innovative solutions for improving performances and management of wastewater treatment processes, also using process mathematical modelling.

The main objectives are performances enhancement in terms of contaminants removal, energy use reduction, sludge production reduction and chemicals consumption optimization.

Possible interventions to be implemented are intended to imply minimum modifications to the plant and, where possible, restricted to process adjustments.

During the project we will develop a new system to monitor process parameters/indicators that could act as a dynamic interface between plant data, analytical data and process technical data.
The system will supply process managers a tool for a more systematic and rational "ordinary" process management and plant efficiency monitoring.
The developed monitoring system will also be useful for research and innovation purposes. For example, the observation of process parameters/indicators trends in the long term will give the opportunity to:

- monitor the general behaviour of the plant;
- analyse the effect of introduced process innovations/changes in a more easy and rational manner;
- identify, potential process weaknesses to be fixed.

The monitoring system will be developed in Castiglione T.se, but the same method could easily be extended to other wastewater treatment plants managed by SMAT.

STATUS
Ongoing

STARTING DATE
September 2018

DURATION
24 months

FUNDING
No

PARTNERS
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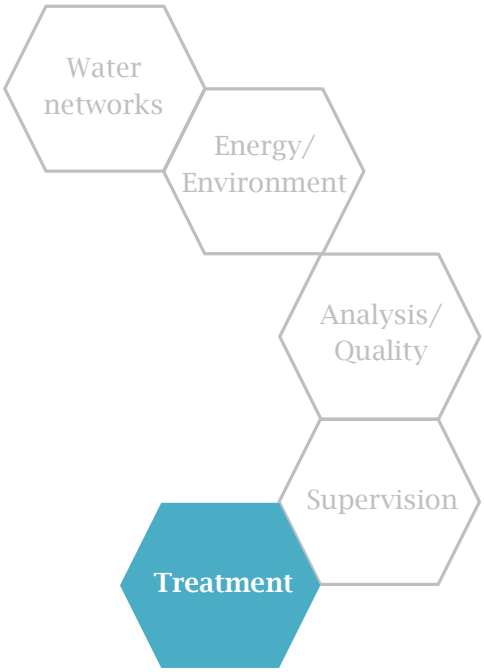
"we will study and test, in laboratory and in the field, innovative solutions for improving performances and management of wastewater treatment processes"

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 the associated drying and disposal costs. This project is devoted to the continuation of a previous experimental work, carried out in collaboration with the Polytechnic University of Turin, to study and test more efficient plant and process solutions to be applied in the sludge treatment line of the wastewater treatment plant in Castiglione Torinese.
The project's stem is in the excellent results achieved during the previous low temperature thermo-alkaline sludge pre-treatment tests that showed 87% increase in methane production.

During the first months, project activities focused on experimental tests, of waste active sludge thermofilic anaerobic digestion carried out in pilot digesters. Secondly, a test on the 2-stage anaerobic digestion of primary sludge was carried out (with low-HRT first stage – acid digestion). Tests were conducted in 10 liters and 300 liters pilot digesters.
Experimental tests will then be primarily dedicated to 2-stage anaerobic digestion of waste active sludge. Moreover, in order to reduce energy and chemicals consumption, as well as treatment plant dimensions, we will test thermo-alkaline treatment for waste active sludge in an intermediate state between primary and secondary stage of digestion.
Experimental results will show which is the best configuration of waste active sludge and primary sludge digestion and the optimal position of thermo-alkaline treatment for waste active sludge.

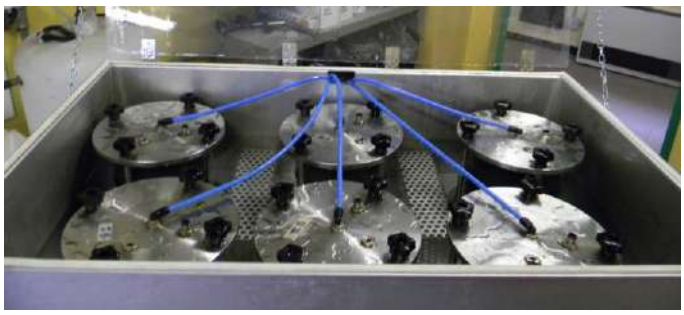
STATUS
Ongoing

STARTING DATE
June 2018

DURATION
24 months

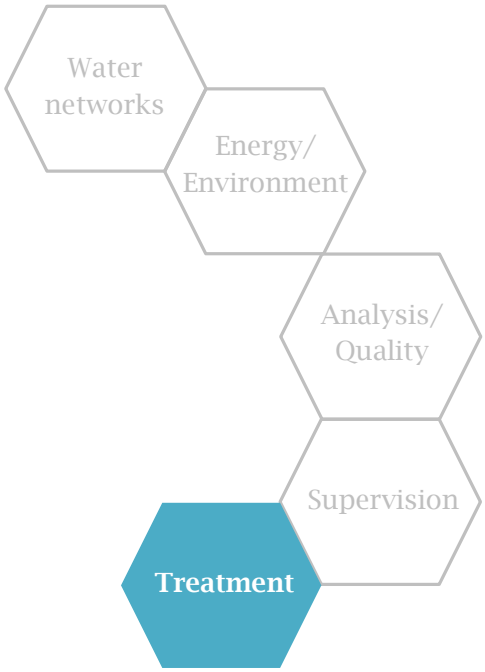
FUNDING
No

PARTNERS
Polytechnic University of Turin



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

MODELING OF URBAN WASTE WATER TREATMENT PROCESSES



Mathematical models of physical, chemical and biological processes of wastewater treatment are instruments of great importance for plant management, since they give the opportunity to simulate the operation and foresee the plant's behavior in response to changes in operational parameters. The models (for sure the most renowned is ASM – Active Sludge Model) allow to optimize operational management, in terms of treatment performance, sludge production, energy consumption and chemicals consumption.

During a previous project on the same theme, implemented in collaboration with Polytechnic University of Turin, a model was built for one of the four parallel modules that compose the water treatment line of Castiglione T.se plant. The objective of this project is to extend the model implementation to the other three treatment modules using a commercial software.

During the first months of the project, the model will be developed and calibrated, both in stationary and dynamic conditions, based on plant data, on-field measurements and dedicated sampling and laboratory analysis campaigns.

Later, activities will focus on simulations aimed at process optimization and at the definition of adequate plant control and regulation strategies (for example aeration, recirculation flows, chemical dosage, etc.).

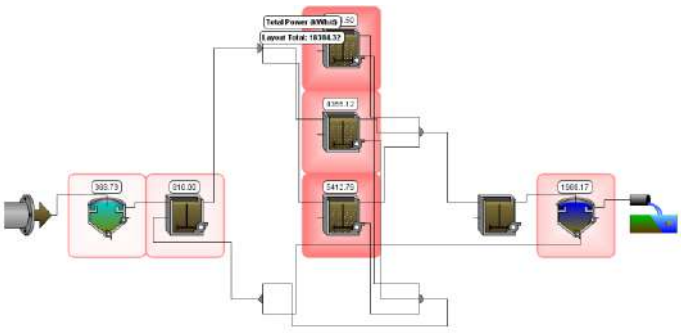
STATUS
Ongoing

STARTING DATE
June 2018

DURATION
24 months

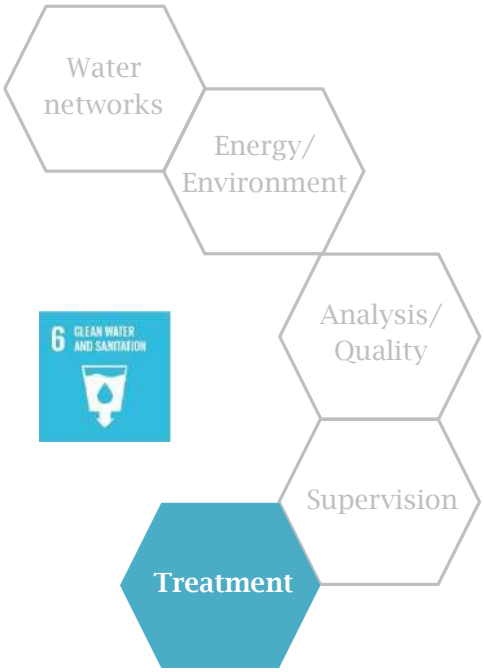
FUNDING
No

PARTNERS
Polytechnic University of Turin



"The models allow the optimization of the operative management, in terms of treatment performance, sludge production, energy consumption and chemical consumption"

HEXAVALENT CHROMIUM TREATMENT PLANTS



Italian legislation on water quality requirements, will introduce a new specific limit for the concentration of hexavalent chromium in water intended for human consumption (the limit will not actually come into force before 2020). As a consequence, water utilities will have to explore new and effective technologies to reduce hexavalent chromium concentration in drinking water below 10 µg/l.
The project has the purpose of supporting operational departments in finding the best solutions for those sites where proper corrective measures should be adopted.

The first trial started in a municipality with less than 500 inhabitants, a mean average flow rate of 0,5 l/s and hexavalent chromium concentration just above to the future regulatory limit; in this case, operational issue are fundamental in selecting a suitable solution, since no permanent workforce is available at the plant premises.
The choice has fallen 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 simpler. The experimentation started with an existing equipment that was adapted to the new application; the plant is operational since mid-June 2017.

The obtained results showed a good resin performance that could be improved with a pre-treatment for lower pH. In 2018, new plants for hexavalent chromium treatment have been started. Part of them were equipped with WBA resins and partly with Strong Base Anion (SBA) resins (both used in single-pass mode); in 2019 it will be possible to compare plants performances.

STATUS
Ongoing

STARTING DATE
March 2017

DURATION
30 months

FUNDING
No

PARTNERS
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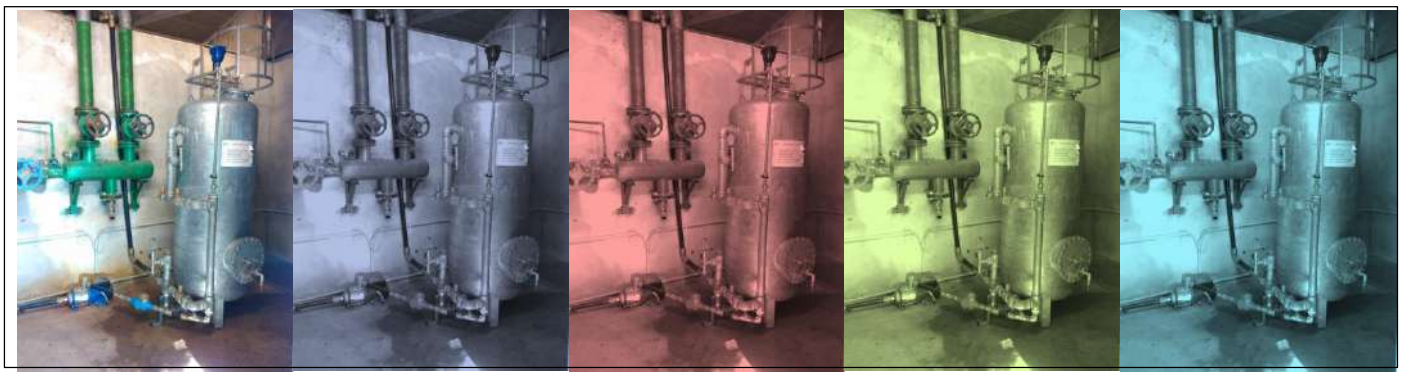
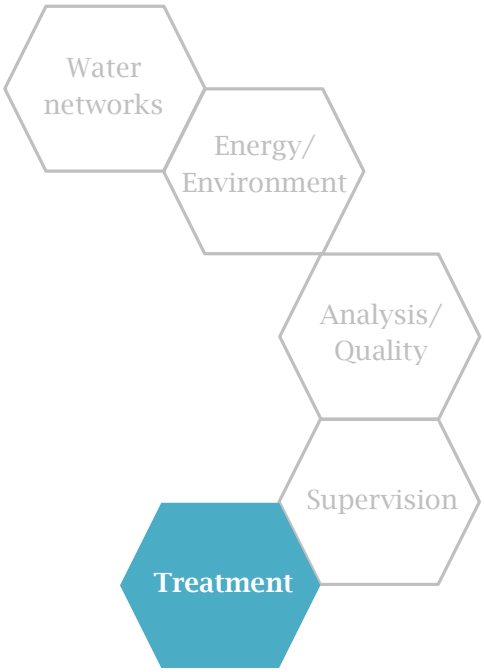


"In Italy, the future entry into force of a new specific limit on hexavalent chromium makes it necessary for water utilities to find best technologies to reduce hexavalent chromium concentration in drinking water below 10 µg/l"

ASSESSMENT OF DISINFECTION METHODS IN MIDDLE SIZE TREATMENT PLANTS



Several studies pointed out that treated and non-treated wastewater is the main responsible for the spread of microorganisms in water ecosystems. Since conventional treatment processes might be insufficient to remove the microbial load, an additional disinfection phase is necessary before effluents are returned to the environment. This would reduce hygienic risks and limit toxicity for reception water bodies. The purpose of this study is to compare the effectiveness of three disinfection methods (sodium hypochlorite, peracetic acid and UV) in deactivating pathogens and indicators in three treatment plants managed by SMAT. An assessment of effluents toxicity has also been performed.

During the first phase (September 2017-September 2018), samples collected before and after the disinfection system were analyzed by the DSSPP through molecular biology techniques for *Campylobacter* (spp., *jejuni* e *coli)*, *E. coli* O157:H7, virulence genes (*eae*, *stx*1, *stx*2) and *Salmonella* spp. At the same time, the department also performed a search for microbiological indicators and a toxicity assessment with con *V. fischeri*, *D. magna* and *P. subcapitata*. SMAT was in charge for water sample collection, chemical analysis and toxicity e valuation through Microtox™.
Campylobacter was not found in tested samples. Only one sample, disinfected with aloacetic acid was contaminated by *E. coli* O157:H7 and *stx1*. With regard to *Salmonella*, more than 50% of samples collected before disinfection was found contaminated with molecular and culture methods. After disinfection 33% of samples resulted positive according to molecular methods and 17% to culture methods. Every sample treated by disinfection systems was compliant to law requirements for *E. coli* (<5000 UFC/100 ml). The greatest reduction of indicator parameters was obtained in samples treated with sodium hypochlorite. Nevertheless, 60% of them was found to be toxic by all three test methods applied for ecotoxicity evaluation. Statistical data analysis is currently ongoing.

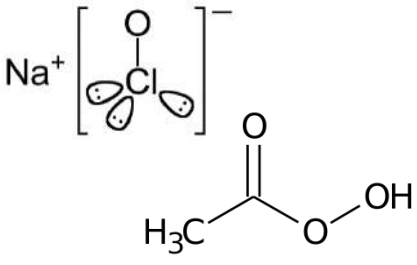
STATUS
Ongoing

STARTING DATE
September 2017

DURATION
18 months

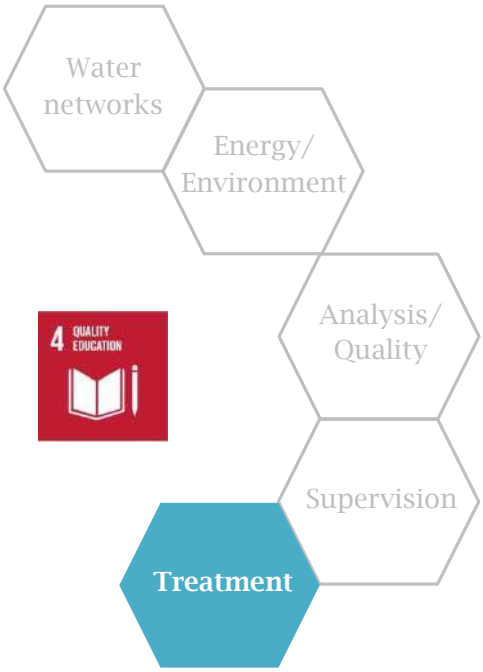
FUNDING
Yes

PARTNERS
Department of Public and Pediatric Health Sciences, University of Turin (DSSPP)



"Hypochlorite resulted to be the most effective treatment in disinfecting wastewater, but the toxicity found in effluents underlines the necessity to evaluate alternative treatment methods"

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.). The project is entirely financed by the European Union in the framework of Horizon 2020 Program - Marie Sklodowska Curie Actions - Innovative Training Networks.

In 2018, researchers (ESRs) were selected and assigned to the 11 beneficiaries (including SMAT) of the fund. The activities carried out within SMAT (in agreement with the Individual Training Plan developed for the ESR), mainly focused on the definition and validation of a technique UHPLC-MS/MS for PFAS (Perfluoroalkylated substances) detection. Through multivariate spatial statistical analysis techniques, and by correlating potentially polluting sites in the area with PFAS monitoring results, we developed an innovative methodology for the definition of monitoring plans based on risks assessment (in agreement with the Water Safety Plans principles). The evaluation and management of risks in catchment areas represent the first protection of the water supply chain. The selection of pollutants to be investigated was determined by the research performed, within the project, by the partner INERIS, based on the results obtained by NORMAN European Network. The creation of shared databases at European level (https://www.norman-network.net/empodat) represents an essential interfaces between science and policy, in order to orient the EU Commission and other institutions through “position papers”.

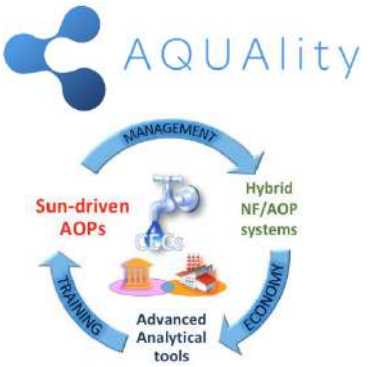
STATUS
Ongoing

STARTING DATE
October 2017

DURATION
48 months

FUNDING
No

PARTNERS
Univ. Turin, Aalborg Universitet, Univ. Piemonte Orientale, Uni. Politecnica de Valencia et al.



“The objective of this European “training through research” inter-disciplinary and inter-sectoral project is to investigate innovative and hybrid methods to remove emerging pollutants from water ”

Cod: LRC_AC_2017_11

Publications and proceedings

Amalfitano S., Levantesi C., Garrelly L., **Giacosa D.**, **Bersani F.**, Rossetti S. Water quality and total microbial load: a double-threshold identification procedure intended for space applications. Frontiers in Microbiology, 2018, 9:2903. doi: 10.3389/fmicb.2018.02903.

Baiocco G., Giraudo M., Bocchini L., Barbieri S., Locantore I., **Brussolo E.**, **Giacosa D.**, **Meucci L.**, **Steffenino S.,** et al., 2018: A water-filled garment to protect astronauts during interplanetary missions tested on board the ISS, *Life Sciences in Space Research*, 18,1-11.

Binetti R., Calza P., **Costantino G.**, **Morgillo S.**, **Papagiannaki D.** Perfluoroalkyl Substances Assessment in Turin Metropolitan Area and correlation with potential sources of pollution according to the Water Safety Plan risk management approach, *Separations- Determination of Contaminants of Emerging Concern in Environmental Matrices*, in press.

Borzooei S., Amerlinck Y., Abolfathi S., Panepinto D., Nopens I., **Lorenzi E.**, **Meucci L.**, Zanetti M.C. Data scarcity in modelling and simulation of a large-scale WWTP: Stop sign or a challenge. *Journal of Water Process Engineering*, in press.

Brussolo E., Toso D., Spatola G., **Sasso M., Binetti R.**: Exploring Nafion adsorption and exclusion potential in metal ion removal from water. *Submitted*.

Campo G., Cerutti A., Zanetti M.C., **Scibilia G.**, **Lorenzi E.**, Ruffino B., 2018. Enhancement of waste activated sludge (WAS) anaerobic digestion by means of pre- and intermediate treatments. Technical and economic analysis at a full-scale WWTP. *Journal of Environmental Management*, 216, 15 June 2018, Pages 372-382.

Giagnorio M., Ruffino B., Grinic D., **Steffenino S.**, **Meucci L.**, Zanetti M.C., Tiraferri A., 2018: Achieving low concentrations of chromium in drinking water by nanofiltration: membrane performance and selection. *Environmental Science and Pollution Research*. doi:https://doi.org/10.1007/s11356-018-2627-5.

Giagnorio M., **Steffenino S.**, **Meucci L.**, Zanetti M.C., Tiraferri A., 2018: Design and performance of a nanofiltration plant for the removal of chromium aimed at the production of safe potable water. *Journal of Environmental Chemical Engineering* 6 (2018), 4467–4475. doi:10.1016/j.jece.2018.06.055.

Kase R., Javurkova B., Simon E.,[…], **Bersani F.**, Perceval O., Kienle C., Vermeirssen E., Hilscherova K, Reifferscheid G., Werner I. Screening and risk management solutions for steroidal estrogens in surface and wastewater. *Trends in Analytical Chemistry*, 2018, 102:343-358. doi: 10.1016/j.trac.2018.02.013.

Könemann S., Kase R., Simon E., […], **Bersani F.**, Hilscherova K., Reifferscheid G., Ternes T, Carere M. Effect-based and chemical analytical methods to monitor estrogens under the European Water Framework Directive. *Trends in Analytical Chemistry*, 2018, 102:225-235. doi: 10.1016/j.trac.2018.02.008.

Pignata C., Bonetta Si., Bonetta Sa., **Meucci L., Giacosa D., Bersani F.,** Cacciò S.M., Sannella A.R., Gilli G., Carraro E. Cryptosporidium contamination in drinking water: a case study in Italy. *Submitted.*

Ruffino B., Cerutti A., Campo G., **Scibilia G., Lorenzi E**., Zanetti M.C. Effect of the hydraulic retention time (HRT) on the methane generation of a two-stage anaerobic digestion process with intermediate treatments for Waste Activated Sludge (WAS). *Submitted*.

Brussolo E., Raco B., Menichini M., Doveri M., Irace A., Masetti G., Provenzale A.: The foothill aquifer system of the Piedmont Alpine zone: geology, hydrogeology, aquifer recharge and groundwater chemistry. *Sesta Conferenza Annuale SISC*, Venezia, Italy, 17-19/10/2018.

Brussolo E., Ferraris S., Gisolo D., Doveri M., Masetti G., Palazzi E., von Hardenberg J., Provenzale A.: Yearly water balance of the Piedmont Alpine zone. *Sesta Conferenza Annuale SISC*, Venezia, Italy, 17-19/10/2018.

Campo G., Cerutti A., Zanetti M.C., **Scibilia G.**, **Lorenzi E.**, Ruffino B. Pilot-scale study of enhanced methane production during anaerobic digestion of waste activated sludge after combination of low thermal (90 °C, 1.5 h) and alkaline (NaOH) pretreatment. *Sludge Management in Circular Economy*, Roma, Italy, 23-25/5/2018.

Cerutti A., Campo G., Zanetti M.C., Polimeno L., **Scibilia G.**, **Lorenzi E.**, Ruffino B. Effect of the Hydraulic Retention Time (HRT) on the efficiency of a two-stage anaerobic digestion with intermediate treatments for Waste Activated Sludge (WAS). *6th international conference on sustainable solid waste management*. Naxos, Greece, 13-16/6/2018.

Papagiannaki D., **Barsotti F.**, **Politi M.**, **Fungi M.**, **Binetti R.**, Fate of Metolachlor and Terbuthylazine in surface water and related drinking water treatment plant, *XENOVAC II Challenges and Solutions related to Xenobiotics and Antimicrobial Resistance in the Framework of Urban Wastewater Reuse*, Limassol, Cipro 10-12/10/2018

Ravina M., Panepinto D., Mejia Estrada J., Toscano S., **De Giorgio L.**, Salizzoni P., Zanetti M.C., **Meucci L.** Integrated system for monitoring of odor emissions from civil wastewater treatment plants. *7th International symposium on Energy from Biomass and Waste*, Venezia, Italy, 15-18/10/2018.

Spatola G., Aime S., Viale A., **Binetti R.**, **Brussolo E.**: Evidence of the presence of structured water at the water-Nafion interface from T1-weighted MRI measurements. *XLVII National Congress on Magnetic Resonance*, Torino, Italy, 19-21/09/2018.

Oral presentations

Bersani F. Disinfezione dell'acqua mediante cavitazione idrodinamica. I driver dello sviluppo. Le utility e l'innovazione: 10 anni di ricerca applicata – Torino, 20/11/2018.

Bersani F., **Giacosa D.** BIOWYSE: un sistema integrato di controllo in tempo reale della biocontaminazione. Festival dell'innovazione e della scienza – Settimo Torinese, 17/10/2018.

Brussolo E.. La ricerca applicata al servizio idrico: esperienze e prospettive. *Convegno FAI (Fondo Ambiente Italiano) Il Futuro dell'Acqua* - Pisa, Italy, 30/11/2018.

Brussolo E. I cambiamenti climatici ed il Servizio Idrico Integrato. *#TEAMUP Event - Climathon 2018* - Torino, Italy, 15/10/2018.

Scibetta M., Octopus: una piattaforma open source per l'integrazione, l'analisi e la visualizzazione dei dati aziendali. *ACCADUEO*, Bologna, 18/10/2018.

Steffenino S., Le strategie per il servizio idrico. *Servizi a Rete TOUR 2018* – Torino, 13-14/06/2018.

Steffenino S., **Meucci L.**, Tiraferri A., Giagnorio M., Zanetti M.C.. Cromo: esperienze di trattamenti tradizionali e innovativi. *Ecomondo 2018* – Rimini, 6 – 9/11/2018.

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- Analysis of emerging pollutants in drinking water
- Hexavalent Chromium treatment plants

Impacts of climate change on groundwater resources

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