smat
CENTRO RICERCHE

RESEARCH ACTIVITIES

JANUARY 2017

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RESEARCH ACTIVITIES

JANUARY 2017

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SMAT Research Center: our commitment to research and innovation

This is our third annual research report: the first one dates back to 2015, at the beginning of a new course for our Research Center, with the hiring of five young researchers exclusively dedicated to research and innovation activities, with diverse and complementary expertise in hydraulic and environmental engineering, physics and biotechnology.
Two years later we are pleased to announce our results, proven by the achievements of 2016:

- 13 closed projects
- 23 ongoing projects at the end of the year
- 7 projects opening in 2017
- 2 ongoing projects funded by EU Horizon 2020
- 11 projects in collaboration with industrial partners
- 7 projects awaiting funding approval
- 6 full-time researchers
- 8 among fellows, interns and undergraduate students attending the SMAT Research Center
- 47 SMAT employees involved in research projects
- 4 partnership agreements for research

Anyway, numbers are not enough to describe SMAT commitment to research. We constantly develop our activities to improve drinking and waste water treatments, energy saving, process automation, waste water reuse, forecasting and management model optimization, and more…
In this framework, we would like to highlight a recently initiated study with a considerable impact on the territory. The project, aimed at investigating the consequences of climate change on groundwater resources intended for human consumption, derives from the collaboration among SMAT, CNR-IGG, the DIST Department of the Polytechnic University of Turin, ARPA Piemonte and Società Meteorologica Italiana, and will provide important hints for the implementation of infrastructures needed for the future of our territory. The capability to adapt to climate changes will be one of the greatest challenges for integrated urban water management authorities in the next future.
In 2016 we also embarked on two new 'space-related' projects:
- the first one, BIOWYSE, funded by the EU, aims to develop and validate an integrated real-time biocontamination control system in water networks and humid surfaces onboard the International Space Station and for future space exploration missions;
- the second one, PERSEO, funded by the Italian Space Agency, has the goal to generate a wearable 'water-based' radiation protection system to mitigate the effects of cosmic radiation.
But even though space 'calls us', our 'terrestrial' vocation remains our main focus: among the new studies opening in 2017, we would like to mention the NMR EZ project, about the use of nuclear magnetic resonance techniques to interpret the Exclusion Zone phenomenon, which could allow to produce extra pure water without any environmental impact, and the Haloacetic and Biochar project, aimed at testing industrial process by-products to remove emerging pollutants. Altogether, we can say that we do not lack motivation to keep growing!

Lorenza Meucci

Research Center Director

Paolo Romano

CEO

January 2017

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Projects closed in 2016

BIOFUEL

Energy/Environment

STATUS
Closed

STARTING DATE
April 2011

DURATION
68 months

FUNDING
No

PARTNERS
ENI Donegani Institute

One of the main issues in urban wastewater treatment is the reuse of waste products, in particular sludges produced by primary and secondary depuration processes. This study is aimed at verifying the applicability of the liquefaction treatment, developed by Eni Donegani for the production of biofuel from organic waste, to sewage sludge with good efficiency. The advantages are the conversion of organic substance into biofuel, the reduction of sludge production and the improvement of biological degradation.
Liquefaction tests from mixed sludges (primary and secondary sludegs) have been performed. Biooil, incondensable gases, an aqueous and a solid phase are obtained. Incondensable gas can be destinated, together with biogas, to energy recovery; experimental tests have highlighted that the aqueous phase, enriched in organic substance, can be transferred to aerobic digestion.

The project has demonstrated that liquefaction treatment is more suitable for surplus (secondary) sludges, rather than to sludges produced by primary sedimentation. Nevertheless, the amount of residual inert substance contained in sludge implicates that biofuel production yields are lower than those obtained from other types of waste matrix (as, for example, OFMSW).
Even if the liquid phase resulting from the liquefaction process is treated by anaerobic digestion, the technical and economic framework of the process is, at the moment, not very promising, both for the high investment cost and for the need to extract biofuel with solvents in order to separate it from the solid residual. Nevertheless, the continuous increase of sewage sludge disposal costs could, in the future, bring back the attention on this liquefaction process application.

"One of the main issues in urban wastewater treatment is the reuse of waste products, in particular sludges produced by primary and secondary depuration processes"

USE OF ALGAL BIOMASS FOR HYDROGEN PRODUCTION IN AN INTEGRATED ENERGETIC SYSTEM

Energy/Environment

STATUS
Closed

STARTING DATE
July 2014

DURATION
23 months

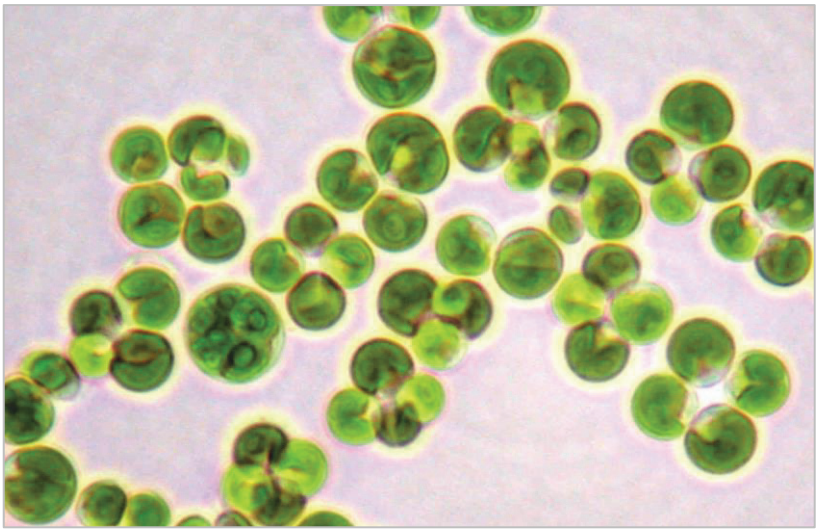
FUNDING
Yes

PARTNERS
Polytechnic University of Turin, Sea Marconi, Environment Park, Hysytech

Water deriving from dewatering of anaerobically treated waste water sludges is enriched in nutrients (nitrogen and phosphorus) and relatively poor in biodegradable organic substances, thus representing an excellent substrate for microalgal growth.

The first phase of the project was aimed at studying and optimizing microalgal proliferation in vitro upon feeding with sludge dewatering-derived water from Castiglione Torinese treatment plant and at selecting the most suitable species and adjusting process conditions. The following experimental phase was dedicated to the cultivation of the selected algae inside a pilot scale photobioreactor with an helicoidal shape for the optimization of process conditions and for testing algal growth rates and nutrient removal efficiencies from water.

Algae grown inside a photobioreactor were then used for hydrogen production through two parallel paths: the first one involved anaerobic fermentation of microalgae, the second one was based on their pyrolysis and gasification. Hydrogen produced by either technology was used, during the following experimental phase, for high efficiency combined heat and power generation using solid oxide fuel cells (SOFC).



During the final phase of the project, we focused on the analysis of the energetic efficiencies, environmental impacts (LCA) and economic analysis of a wastewater-based algae cultivation system. Our analysis outlined that, at present, the system would not be economically convenient if algae were used uniquely for energetic purposes (considering the plant costs and the experimentally measured energetic yields). However, the system could turn out to be interesting for the cultivation of algae used for different purposes characterized by a higher added value (animal feed, cosmetics, etc…).

"Water deriving from dewatering of anaerobically treated waste water sludges is enriched in nutrients (nitrogen and phosphorus) and relatively poor in biodegradable organic substances, thus representing an excellent substrate for microalgal growth"

EMERGING PATHOGENS IN WATER INTENDED FOR HUMAN CONSUMPTION

Analysis/Quality

STATUS
Closed

STARTING DATE
January 2012

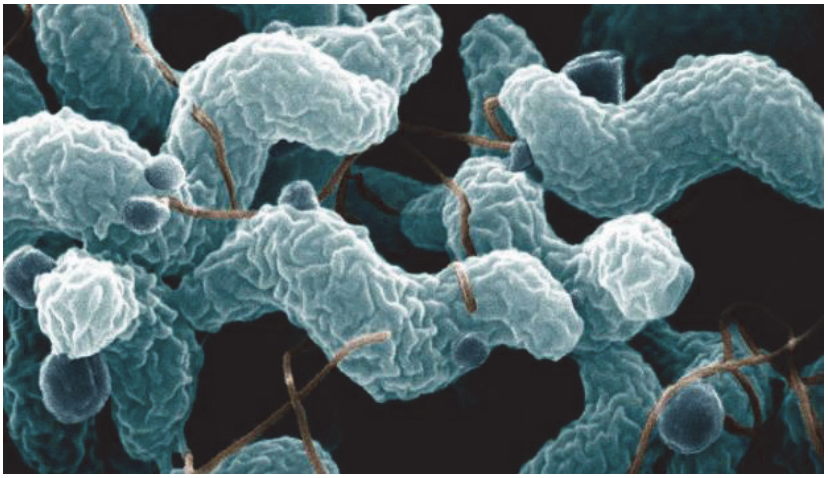
DURATION
60 months

FUNDING
No

PARTNERS
University of Turin

A large number of waterborne diseases are caused worldwide by pathogenic protozoa (325 epidemics between 1900 and 2003, 199 epidemics between 2004 and 2010). *Cryptosporidium spp.* is the aetiological agent that caused most diseases (60,3%), followed by *Giardia lamblia* (35,1%). In 2014, in Europe, 22 water-related epidemics were registered in nine countries (556 cases of desease, 15 of which were hospitalized), and the main bacterial aetiological agents were identified as *Salmonella, Campylobacter* and *Escherichia* (toxin-producing species, such as *E.coli O157:H7*), all of which are pathogens transmitted through the faecal-oral route.

SMAT has been monitoring the presence of Giardia and Cryptosporidium for more than 20 years and this research project, adding biomolecular methods to standard microbiological approaches, allowed us to exclude the presence of two different species of Cryptosporidium that are pathogenic for humans (*C. parvum* e *C. hominis*) and to assess the existence of other emerging pathogens of bacterial origin.



To evaluate the presence of *Salmonella, Campylobacter* and toxin-producing species of *Escherichia coli*, different monitoring campaigns were carried out. Samples were collected during the spring, summer, autumn and winter season, including three different points of surface water catchment for subsequent potabilization treatment. This approach allowed us to characterize the seasonality and geographical spread of such microorganisms.

Salmonella spp. was found in the 38% of the analyzed samples, Campylobacter genus was observed in 56% of them, while no strains of E.coli O157:H7 were found. Testing different samples collected at the inlet and outlet of the lagooning system (located prior to the Po river water catchment for drinking purposes), highlighted the efficacy of this basin in reducing the presence of pathogenic microorganisms. Interestingly, our analysis did not show any correlation between the presence of contaminating microorganisms and the sampling season.

"Between 2004 and 2010, 199 waterborne epidemics linked to pathogenic protozoa were registered worldwide. In 2014, in Europe, 556 cases of disease on a total of 22 epidemics were caused by pathogenic microorganisms spread by water"

RESPIROMETRY TECHNIQUES APPLIED TO ACTIVATED SLUDGE PLANTS

Analysis/Quality

STATUS
Closed

STARTING DATE
January 2014

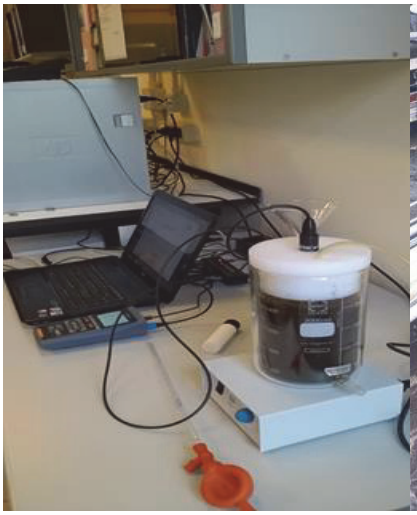
DURATION
24 months

FUNDING
No

PARTNERS
Hera, Iren

The characterization of wastewater at the inlet of a sewage plant represents the major requirement for proper plant dimensioning, optimization and management. A large part of plant designing is realized on the basis of semi-empiric models that use BOD and COD parameters, which are monitored for wastewater process management and as a reference for D.Lgs. 152/2006 discharge limits. Different mathematical models for the simulation of activated sludge processes have been developed over the years; ASM (Activated Sludge Model) models, for example, reached high reliability and strength and are therefore very diffused. These models require an intensive wastewater characterization with a level of detail greater than the one given by BOD and COD, in order to obtain: kinetic and stoechiometric parameter as well as carbon compounds/nutrient fractioning estimation in treated wastewater. COD thus becomes an important parameter because it allows correlation between substrates, biomass and consumed oxygen.

The collaboration with IREN and HERA in the framework of this project has allowed the realization of a respirometer, that is a system used to verify cellular growth processes, endogenous decay, carbon compound removal kintetics, nitrification, substrate characterization and biodegradability. Data obtained with these techniques have been employed for simulation by a modelling software on a big treatment plant with the aim of verifying its applicability.
The overall results represent the starting point for an intensive field application.



"The characterization of wastewater in the inlet of a sewage plant represents the major requirement for proper plant dimensioning, optimization and management"

EFFECT OF THE WASTE WATER TREATMENT PLANT EFFLUENT ON RIVER WATER QUALITY

Analysis/Quality

STATUS
Closed

STARTING DATE
December 2012

DURATION
48 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

The italian Directive 2000/60/CE, the Legislative Decree No. 152/2006 and the Water Protection Plan define quality goals of surface water and groundwater resources. The Turin stretch of the Po river receives pollutants from different sources, both localized and diffused, with high amounts of nitrogen and phosphorus due to eutrophication. The waste water treatment plant of Castiglione Torinese discharges its resulting effluent modifying the river quality, so the river stretch between the monitoring stations of San Mauro Torinese and Chivasso was analyzed in this study. The study was carried out collecting and analyzing historical data obtained from Piedmont Regional institutions, ARPA, our in-house data collected during the 2013-2015 sampling campaign and SECA and SACA indexes to verify the ecological and environmental status of the river.

The river stretch located between San Mauro Torinese and Castiglione Torinese has higher pollutants levels, with a better overall situation downstrem, towards Chivasso.
Between San Mauro Torinese and Brandizzo pollutants mainly derive from the treatment plant effluent, discharged in a river stretch characterized by a limited flow due to water catchment in the Cimena channel located in San Mauro Torinese. In the following sections of the river, pollutants are mainly due to diffused sources.
Between San Mauro Torinese and Castiglione Torinese river banks are strongly cemented, thus limiting the development of tree vegetation and altering the ecological status. In the following stretch, between Brandizzo and Chivasso, river quality improves due to the water input from Orco and Malone tributaries and to the self-purification efficiency of the river itself. To obtain a “good” ecological status over the whole river stretch analyzed in this study, attention should be drawn to both improving the reduction of nutrients discharged from the waste water treatment plant with innovative treatment processes and adopting restrictive measures to decrease eutrophication in the stretch of the river located upstream of the treatment plant.

“Innovative treatment solutions and restrictive measures to decrease eutrophication in the stretch of river located upstream of the waste water treatment plant will help to obtain a “good” ecological status throughout the Turin stretch of the Po river”

INTEGRATING HYDRAULIC MODELING AND SCADA FOR DEMAND FORECASTING AND WATER BALANCE

Water networks

STATUS
Closed

STARTING DATE
December 2014

DURATION
24 months

FUNDING
No

PARTNERS
Hera, Iren

In water supply system management, the real-time measurement of flow rates in pipes allows rapid detection of possible anomalies in the distribution network (bursts, malfunctioning, …). In addition to this, demand forecasting is important in view of reducing energy consumption. In this context, the project aimed to identify smart systems able to provide data about physic and hydraulic variables in real-time. Another goal of the developed smart systems is the ability to forecast water demand within the following few hours.

The objectives were pursued with two different approaches. The first involved the installation of domestic meters equipped with remote reading in two pilot districts. Specifically, a number of counters equal to about 5-10% of the total was installed, with the aim of extending the information detected by them to the totality of the meters present in the districts, using statistical algorithms called "exit-poll".
The second approach involved the implementation of two prediction algorithms of the inflow rate into the water distribution network and their application to some pilot sites.
Good results were obtained in both cases. Based on the experience gained during the project, it was possible to identify both the critical issues and the possible consequences of predictive modeling for water distribution network management.

"The project aims to identify smart systems that are able to provide data about physic and hydraulic variables in real-time"

MATHEMATICAL MODELING OF AVIGLIANA WATER DISTRIBUTION NETWORK

Water networks

STATUS
Closed

STARTING DATE
September 2015

DURATION
6 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

The purpose of the research project is the creation of a mathematical model of the water network of Avigliana, a town of 12'230 inhabitants in the metropolitan area of the city of Turin, located about twenty kilometers west of Turin in a morainic amphitheater in the terminal part of the Susa Valley toward the plain, in a diverse and complex territory known as the morainic amphitheater of Rivoli-Avigliana.
The use of a numeric model of the water distribution system opens to many opportunities for future analysis, improvement and management optimization of the network. Applications may include energy optimization, study of risk scenarios and emergency, districtualization of the network, modeling of chemical substances introduced into the network, definition of zones of influence, water age assessment.

The model was built and calibrated using a code written in the Python language, created in order to facilitate and accelerate the construction of mathematical models of medium-large networks, such as Avigliana, characterized by 96 km of pipes transformed into a network of 1,418 branches and 1,620 nodes, 260 gate valves, 8 tanks, 7 wells, 20 pumps. In addition to the research stage, cataloging and reorganizing data for the construction of the model gave us the opportunity to get a general view of the information already collected by the company but not yet properly gathered and organized. This revealed many interesting aspects that allowed to increase the general knowledge. The model, once calibrated through a series of pressure and flow measurements, was used for the definition of a districtualization plan that it currently being implemented.

"The use of a numeric model of the water distribution system opens to many opportunities for future analysis, improvement and management optimization of the network"

THIRD MILLENNIUM SCADA: GUIDELINES FOR SMART APPLICATION OF DATA

Supervision

STATUS
Closed

STARTING DATE
December 2014

DURATION
24 months

FUNDING
No

PARTNERS
Hera, Iren

The project aimed at identifying the guidelines for the generation of a future SCADA system by taking advantage of the acquired data potential to upgrade the existent system or to implement a new one. In particular, optimal architecture of future SCADA systems will be identified based on the size of the infrastructures to be managed and on the features of the acquired measures. The new control strategies will be also based on the results of numerical modelling of the water supply system behavior. The capability to automate processes and actions "moves" the work towards an increased control in order to take more informed decisions.

The guidelines developed within the framework of the project addressed the issues of security, connectivity, contraposition between local and central intelligence, IoT technologies, use of mathematical modeling, management of different communication protocols, implementation of "smart" alarms and of collected data sharing.
Application of these new guidelines allows to improve many aspects of SCADA management, for instance the integration of data acquired by remote control with those deriving from other databases, or the use of models to support decisions as well as the identification of a suitable perimeter designed to protect and insulate the dedicated and independent environment of SCADA.

"Application of these new guidelines allows to improve many aspects of SCADA management, for instance the integration of data acquired by remote control with those deriving from other databases, or the use of models to support decisions"

STUDY OF INNOVATIVE TREATMENTS IN THE WATER SUPPLY SYSTEM: *"EXCLUSION ZONE"*

Treatment

STATUS
Closed

STARTING DATE
December 2014

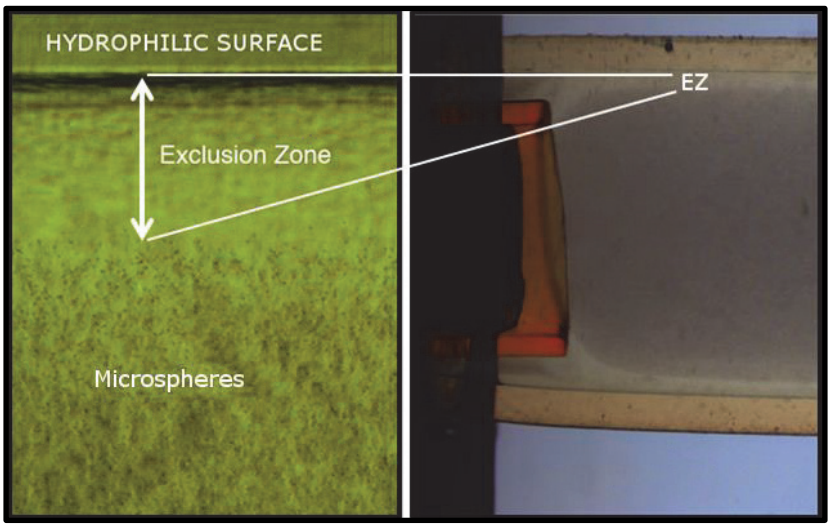
DURATION
18 months

FUNDING
No

PARTNERS
Hera, Iren, Polytechnic University of Turin, University of Washington

It has been extensively observed that, when solutions or suspensions are in contact with hydrophilic surfaces, particles migrate away from these surfaces, leaving a region of 'pure-water' called Exclusion Zone (EZ). This particle-free zone extends from the surface interface up to hundreds of micrometers, as a kind of 'self-depuration' phenomenon. This anomalous behavior was observed from researchers of different fields and for various materials, such as biological tissues, white blood cells, ion exchange membranes and different polymers.

This project investigated the exploitation potential of the Exclusion Zone phenomenon (EZ) for water purification as an alternative methodology for water treatment, with respect to pollutant removal and contact periods. Experimental tests revealed a good purification efficacy of the laboratory prototype currently in use against different metals, chemical and microbiological pollutants.



Notably, the average concentration reductions observed are: between 20% and 60% for metals (with spikes higher than 75% of reduction), between 40% and 80% for pesticides with triazine ring, 70% for organic compounds such as methylene blue and an order of magnitude for some microbiological pollutants such as *Candida* and *Raphidocelis subcapitata* algae.

These results led to the decision to invest additional resources for deepening understanding the EZ phenomenon with a multidisciplinary approach which will include modelling of the EZ phenomenon at the microfluidic level, Nuclear Magnetic Resonance (NMR) analyses to characterize the particle-free zone, the study of the best structure and geometry of the system to increase process performances (in terms of both efficiency and productivity) and evaluation of different hydrophilic materials for future full-scale applications.

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

INNOVATIVE AND 'GREENER' TREATMENTS FOR DRINKING AND WASTE WATER: USE OF FERRATE

Treatment

STATUS
Closed

STARTING DATE
December 2014

DURATION
24 months

FUNDING
No

PARTNERS
Hera, Iren, Polytechnic University of Turin

Commonly employed oxidizing/disinfectant compounds used in water treatment induce the formation of unwanted byproducts often characterized by intrinsic toxicity. Despite being very "strong", a novel oxidizing agent called ferrate (Fe VI) does not produce dangerous byproducts. On the contrary, its byproducts, in the form of ferric compounds (Fe III) that can act as coagulating agents, can be rather beneficial. Ferrate could be therefore used for water treatment with three major aims: 1) to promote degradation/removal of organic and inorganic matter (including emerging pollutants) through oxidation; 2) to disinfect and destroy microorganisms; 3) to remove solid/colloidal material and heavy metals by improved coagulation.

During the last year of project activities, carried out in collaboration with Hera and Iren, with the active support of the Polytechnic University of Turin, ferrate performances have been evaluated trough jar tests at lab scale in several operative conditions and on multiple different pollutants of interest. In particular, tests have been performed on raw waters, wastewaters and pure water with specific contaminant addition.

Experimental results have pointed out good disinfection performances and moderate removal of manganese and pesticides, whereas removal of other kind of organic molecules resulted poor or null.

Overall, this experimental treament has not shown adequate efficacy and its technological application does not appear promising. For these reasons the setup of a system to produce ferrate in situ and the following experimental phase on a pilot scale have not been undertaken.

"Despite being very "strong", a novel oxidizing agent called ferrate (Fe VI) does not produce dangerous byproducts. On the contrary, its byproducts, in the form of ferric compounds (Fe III) that can act as coagulating agents, can be rather beneficial"

BENCHMARKING ADVANCED CONTROL OF AERATION SYSTEMS

Treatment

STATUS
Closed

STARTING DATE
December 2014

DURATION
24 months

FUNDING
No

PARTNERS
Hera, Iren

The technology market in waste water treatment has recently witnessed a rapid development of techniques for advanced control of aeration systems in the biologic oxidation compartment (typically the most energy-consuming sector of waste water treatment), that allow a drastic reduction of energy consumption and an improved abatement of pollution loads.

The project, in collaboration with Hera and Iren, was aimed at evaluating and comparing, through the benchmarking of "functionality indexes", different advanced regulation systems of aeration installed within the wastewater treatment plants of the three partner companies. This approach should allow a more objective evaluation of the real advantages in terms of process control, cost/energy reduction and pollutant removal.
The first part of the activities was devoted to the analysis of the regulation systems currently applied to the wastewater treatment plants managed by the partners and to the selection of the more interesting plants for the performance comparison. Data where then gathered and analyzed for the selected plants.
In particular, among SMAT plants, the analysis focused on Castiglione Torinese plant, where an aeration regulation system based on ammonia and nitrate online monitoring inside active-sludge tanks was installed few years ago. Some of the control measures analyzed are based on intermittent aeration, i.e. on sequencial nitrification and denitrification performed in the same tank.
Comparison of consumption indexes after the introduction of the various control technologies in the selected plants outlined an increase in pollutant removal performances and a reduction in energy consumption for aeration in the range of 15-30%. The differences between improvements reached at different plants are mainly due to the index taken into consideration, the plant size, the regulation efficiency starting point of the plant, and, obviously, the aeration control technology examined.

"The project is aimed at evaluating and comparing, through the benchmarking of "functionality indexes", different advanced regulation systems of aeration installed within the premises of the three partner companies"

ORGANIC FRACTION OF MUNICIPAL SOLID WASTES (OFMSW)

Treatment

STATUS
Closed

STARTING DATE
September 2015

DURATION
12 months

FUNDING
No

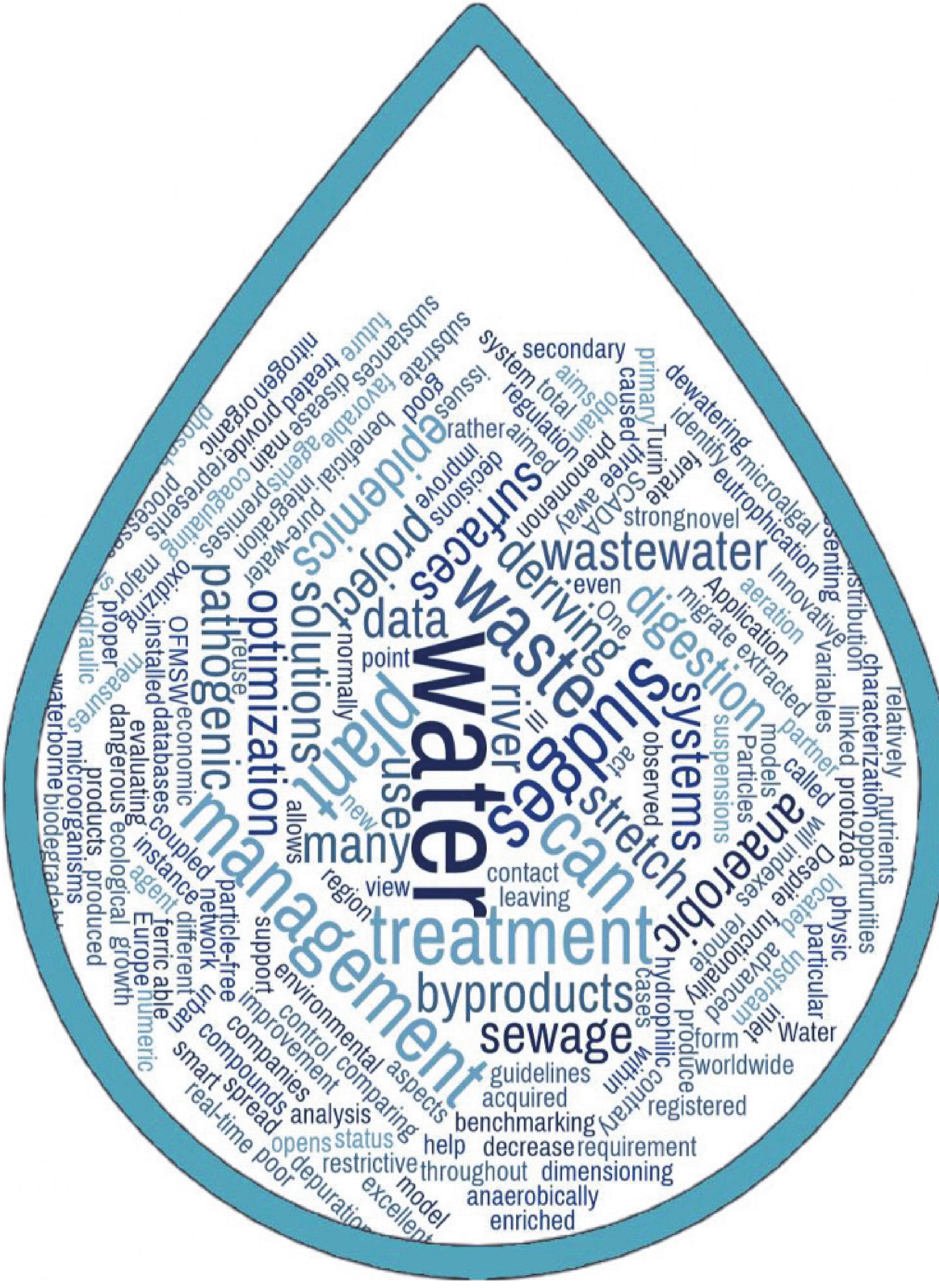
PARTNERS
Risorse Idriche

The organic fraction of municipal solid wastes (OFMSW), especially that coming from an efficient differentiated waste collection, is a valuable resource, although not always acknowledged. Indeed, from OFMSW, it is possible to recover energy and organic matter to be used as soil fertilizer. This potential is not always exploited and often OFMSW undergoes sub-optimal treatments.

Since OFMSW is rich in organic matter, it can be treated through anaerobic digestion with different operative conditions (dry, semi-dry, wet) for biogas production that can be used for direct energy recovery (cogeneration of electrical and thermal power) or for an upgrading treatment or biomethanation (a treatment for methane production through biogas purification) and the introduction in the natural gas distribution grid.
OFMSW anaerobic digestion is even more favorable, from an environmental and economic point of view, when coupled with anaerobic digestion of sewage sludges. Indeed using already existing facilities and plants (those for sewage sludge treatment) is undoubtedly and clearly convenient because, with minor modifications, these plants can be converted into anaerobic co-digestion plants and receive organic wastes, thus recovering biogas and energy, with their production potential that would be otherwise wasted.

The aim of this project was to develop a feasibility study and the preliminary design of an anaerobic co-digestion plant for OFMSW and sewage sludges in the premises of a wastewater treatment plant managed by SMAT and of a composting facility for the production of a soil fertilizer from the digestate of the anaerobic treatment. As a result, two types of waste (OFMSW and sewage sludges) would be transformed into two products (biogas and compost).
During the feasibility study, we considered different options for an efficient pre-treatment and co-digestion of OFSMW. Moreover, we evaluated two technologies for biogas use: cogeneration and biomethanation. The study pointed out the technical and economic feasibility of the proposed process, provided that the plant size is large enough to receive a sufficient quantity of OFMSW, so that capital costs would result appropriate in relation to the expected economic income (economy of scale).

"OFMSW anaerobic digestion is even more favorable, from an environmental and economic point of view, when coupled with anaerobic digestion of sewage sludges"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Water

Ongoing projects

DEMONSTRATION OF LARGE SOFC SYSTEM FED WITH BIOGAS FROM WWTP

Energy/Environment

STATUS
Ongoing

STARTING DATE
September 2015

DURATION
60 months

FUNDING
Yes

PARTNERS
Polytechnic University of Turin, Convion Oy, VTT, Imperial College of Science, Technology and Medicine, Risorse Idriche

The high calorific value of biogas deriving from anaerobic digestion of urban westewater treatment sludge makes it suitable for the production of electrical and thermal energy. Currently, biogas is used in boilers or internal combusion engines that, combined with electric power generation systems, represent the most widespread systems for biogas energy recovery.
An innovative technology is represented by the use of Fuel Cells that allow the achievment of a higher electrical productivity and the reduction of total emissions taking advantage of an electro-chemical process with high efficiency and virtually free from pollutant production.

In particular, Solid Oxide Fuel Cells (SOFC) are new generation cells working at a temperature of about 850 °C and able to use purified biogas as fuel. Indeed, biogas requires to be treated to remove pollutants, especially sulfur compounds and silicon (siloxanes), prior to use.
The use of SOFC with biogas derived from anaerobic digestion has already been tested by SMAT in collaboration with the Department ENERGIA (Energy) of the Polytechnic Univeristy of Turin during the European demonstration project SOFCOM. The project DEMOSOFC, also cofunded within the framework of the Horizon 2020 program, foresees the industrial scale implementation of these cells through the installation of three 58 kWe SOFC at the SMAT plant located in Collegno (TO). Currently, this represents the largest installation with SOFC cells in Europe and the largest in the world with SOFC cells powered by biogas.

After obtaining the required authorizations from administrative bodies, the plant is now neing installed. Set up is expected for summer 2017.

"The project DEMOSOFC represents the largest installation with SOFC cells in Europe and the largest in the word with SOFC cells powered by biogas"

ENERGY BALANCE OF CASTIGLIONE TORINESE SEWAGE PLANT

Energy/Environment

STATUS
Ongoing

STARTING DATE
January 2016

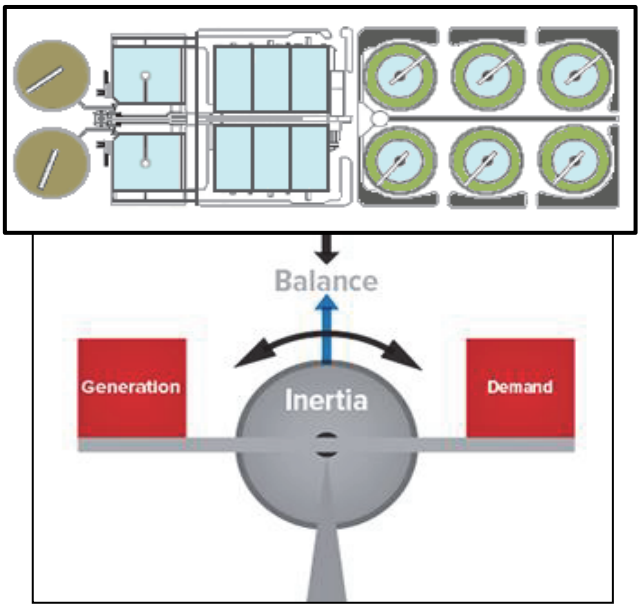
DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Energy power is one of the most expensive cost items of a sewage plant. Consequently, a careful evaluation of energy consumption, plant efficiency, process management and the identification of critical points are major needs. This is the goal of this research project, representing the follow up of previous analyses already carried out in collaboration with the Polytechnic University of Turin.

During the first phase of the project we evaluated the efficiency of oxygen transfer in the activated sludge basins and its energy consumption. The actual energy need and the management, monitoring and control of aeration processes were considered. Time series analysis was carried out on analytical data and on the operative data of the turbochargers that supply air to the biological oxidation basins. Data collection campaigns were carried out to gather process data (such as dissolved oxygen and blown air) and waste water quality data along the treatment process (BOD, COD, organic nitrogen, ammonia and SSV).
The results of this project will delineate some technological hypotheses for the upgrading of the oxygen transfer in the activated sludge basins and its energy consumption, evaluating the latest available products. Innovative control technologies will be considered, with a comparative analysis including similar treatment plants.



"A careful evaluation of energy consumption, plant efficiency, process management and the identification of critical points are major needs for waste water treatment plants"

IMPACTS OF CLIMATE CHANGE ON GROUNDWATER RESOURCES INTENDED FOR HUMAN CONSUMPTION IN THE TURIN AREA

Energy/Environment

STATUS
Ongoing

STARTING DATE
August 2016

DURATION
30 months

FUNDING
No

PARTNERS
CNR-IGG, Polytechnic University of Turin (DIST), ARPA Piemonte, Società Meteorologica Italiana

Climate change impacts people, societies, economic sectors and ecosystems through the interaction of danger, exposure and vulnerability. 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.

SMAT provides integrated water management services in a wide and geographically complex area, exploiting many and diverse supply sources. Groundwater resources represent about 80% of the whole SMAT supply (in terms of volume). This research project will estimate the vulnerability of groundwater resources to climate change effects as well as their interaction with surface water.

This vulnerability will be explored both in quantitative (water availability) and qualitative (maintaining of physical and chemical characteristics) terms. The study will be carried out in the geographical area managed by SMAT, on a time scale of ten to twenty years. Using probabilistic forecast approaches, different potential scenarios will be outlined. These scenarios will form the quantitative basis for the definition of future guidelines and strategic developments, for both infrastructure planning and water management and provisioning. This knowledge base will be a major contribution for both integrated urban water management and water governance measures, in a general context that stimulates and supports participatory planning.

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

EVALUATING THE PRESENCE OF ASBESTOS FIBERS IN SMAT WATER

Analysis/Quality

STATUS
Ongoing

STARTING DATE
November 2012

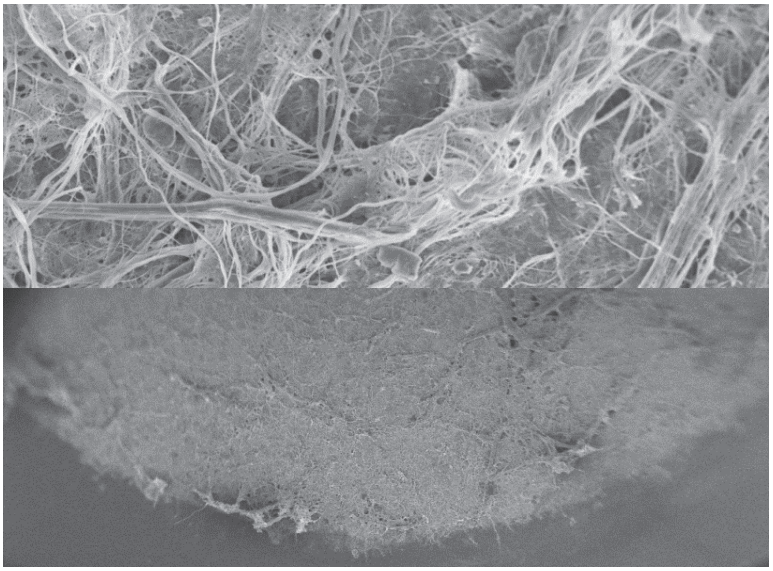
DURATION
60 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

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

Overall, SMAT water networks are only moderately affected by this problem; nevertheless, SMAT launched this project in view of surveying distributed water in the municipalities with known presence of cement-asbestos in drinking water mains and distribution pipes. Samples were analyzed by SEM technology at the Asbestos Laboratory at DIATI, Polytechnic University of Turin.
Up to now, 282 samples have been analyzed: in 43% of them, no asbestos was found; in the remaining 57%, the value was almost always under the USEPA threshold level (most values were at least 2 log less than the level set by USEPA). Besides counting fibers in supplied water, this project will study any possible correlation between water quality and the presence of asbestos.



"Among more than 280 samples tested so far, we have not detected significant amounts of asbestos fibers derived from water pipes. Values fall below the limit set by USEPA"

DATA MANAGEMENT FROM ON-LINE ANALYZERS AND LABORATORY MANAGEMENT SOFTWARE

Analysis/Quality

STATUS
Ongoing

STARTING DATE
December 2014

DURATION
36 months

FUNDING
No

PARTNERS
Hera, Iren

Over the last few years, utilities belonging to the Integrated Water Service have been equipped with mobile instrumentation to digitize all phases of sampling and analysis activities (e.g. in situ surveys or real-time anomalies management) and with online analyzers. These devices drastically improved the service quality in terms of security and productivity, thanks to the amount of available data and their acquisition continuity. The regulatory framework is considering the opportunity to integrate and use online-measured quality data for compliance assessment purposes.

Accordingly, the project initiated by SMAT in collaboration with Hera and Iren identified the development areas to interface more efficiently mobile devices with laboratory management software (security, quality and traceability of the data).
Subsequently, the parameters for which online analyzers were evaluated to be more useful were chosen in agreement with operative lines, considering those with major time-saving advantages using online analysis. All the partners involved in the project are currently carrying out pilot tests on the identified parameters (algae, turbidity and aluminum). Operative procedures to use online analyzers for management purposes are being established and tested. In the final phase of the project, a general data validation procedure will be developed. This approach will make the laboratory and management processes more efficient in terms of expertise, resources and timing.

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

EFFECT-BASED AND CHEMICAL ANALYTICAL MONITORING FOR STEROIDAL ESTROGENS

Analysis/Quality

STATUS
Ongoing

STARTING DATE
April 2015

DURATION
24 months

FUNDING
No

PARTNERS
Italian Institute of Health, Swiss Center for Applied Ecotoxicology, Bio Detection Systems, IRSA-CNR and others

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

Concomitantly with the chemical determination of the three molecules (by HPLC MS-MS), samples from superficial and treated waste water from all over Europe were analyzed using six innovative 'effect-based' techniques, able not only to determine the presence of a substance, but to reveal its possible biological effect even at extremely low concentrations (pg/l range) independently from the identification of the specific compound causing the effect, thanks to biotechnological sensors. The sampling campaign ended in 2015 and the analytical tests are currently still ongoing by some of our project collaborators. Based on the results generated so far, in particular those obtained by 'effect-based' methods, we highlight the presence of endocrine disruptors in the Po river, both in the environment and post-waste water treatment, at levels below the threshold suggested by the European Union and an overall acceptable efficiency of the SMAT waste water treatment plant in Castiglione Torinese (based on preliminary data, third out of the seventeen analyzed in Europe).

"Samples from superficial and treated waste water from all over Europe were analyzed using innovative 'effect-based' techniques, able not only to determine the presence of a substance, but to reveal its possible biological effect"

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

Analysis/Quality

STATUS
Ongoing

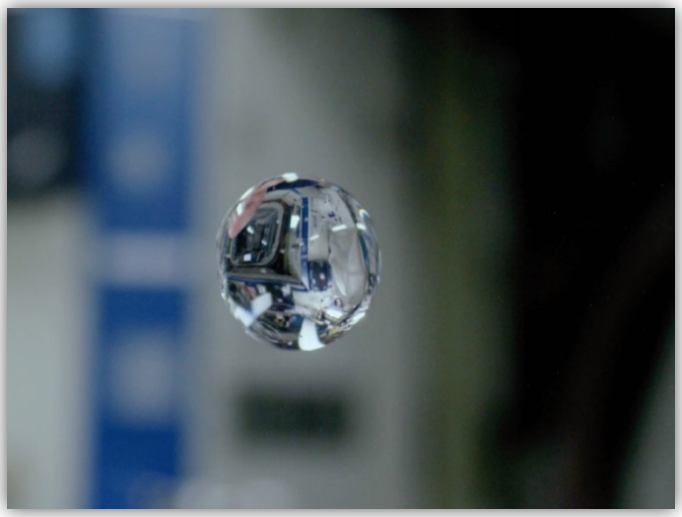
STARTING DATE
December 2015

DURATION
36 months

FUNDING
Yes

PARTNERS
TAS-I, ESF, CNR, GLBio, Liewenthal Electronics Ltd, University of Florence, AquiSense, A-ETC

As demonstrated in several years of ground studies and actual space operations, humid surfaces and wet systems are the most prone to microbial contamination. Space exploration requires the development of more reliable, rapid, efficient and safe methods for preventing, monitoring and controlling biocontamination within human confined environments. These methods should be automated, simple, lightweight and with minimal consumables. As a recognized expert in all steps of drinking water management as well as in water production for the International Space Station (ISS), SMAT was invited to participate along with other international partners in a collaborative project funded by the European Union within the framework of the Horizon 2020 program.



The BIOWYSE project aims to develop and validate an integrated real-time biocontamination control system to prevent, monitor and mitigate microbial contamination risks in water networks and humid surfaces onboard ISS and for future human space exploration missions. The BIOWYSE consortium is designing, building and testing innovative prevention, biomonitoring and UV light-based mitigation modules, which will be then integrated in a compact system. A portable prototype will be further tested in the laboratory and then moved to selected locations for field investigation, to demonstrate its ability to operate under actual conditions. The device should have full potential for exploitation within several space programs, and commercial applications such as confined habitats, hospitals and water distribution networks. During the first year of the project, SMAT played an active role in the prototype planning. Now efforts are moving to the next steps, including system calibration with representative water samples and field test validation of the assembled equipment in view of both space and terrestrial applications, for which a spin-off strategy will be expressly designed.

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

PERSEO - PERSONAL RADIATION SHIELDING FOR INTERPLANETARY MISSIONS

Analysis/Quality

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 hazard to the crew is one of the main showstopper for space exploration and passive radiation shielding currently represents the only feasible technology to allow human deep-space missions. The space radiation environment is mainly constituted by Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE), and the exposure to these highly energetic particle fields entails significant risks for astronauts, possibly inducing both acute and long term effects. In particular, SPEs have the potential to to deliver high radiation doses, eventually causing the haematopoietic syndrome and compromising the bone marrow. Moreover, during future space exploration or planetary missions, astronauts might spend longer periods in space and cope with more frequent Extra-Vehicular Activities. This scenario requires 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 involved in long duration deep-space missions. Monte Carlo simulations were performed to identify the most radiosensitive organs in the human body (spine, gonads, intestine and lymphatic organs) and the appropriate shielding materials. Water, already available on the International Space Station (ISS), has shown high shielding properties and is always accessible for astronauts. SMAT is designing and building bags (made of a polymeric inert material) to be inserted into the inflatable suit PERSEO. This system will be sent to the ISS and tested by the astronauts to check of wearability-related aspects, as well as simplicity of filling and discharging. Furthermore, water shielding properties will be tested using ALTEA/LIDAL detector, available on the ISS, on a bag filled with flight water supplied by SMAT that will be sent to the ISS already.

"Radiation hazard to the crew is one of the major concerns for space exploration, possibly inducing both acute and long term effects. The goal of PERSEO project is to study and develop innovative wearable radiation protection systems to mitigate the effects of cosmic radiation on astronauts"

WATER SAFETY PLANS MODELS AND CASE STUDIES

Analysis/Quality

STATUS
Ongoing

STARTING DATE
April 2016

DURATION
22 months

FUNDING
No

PARTNERS
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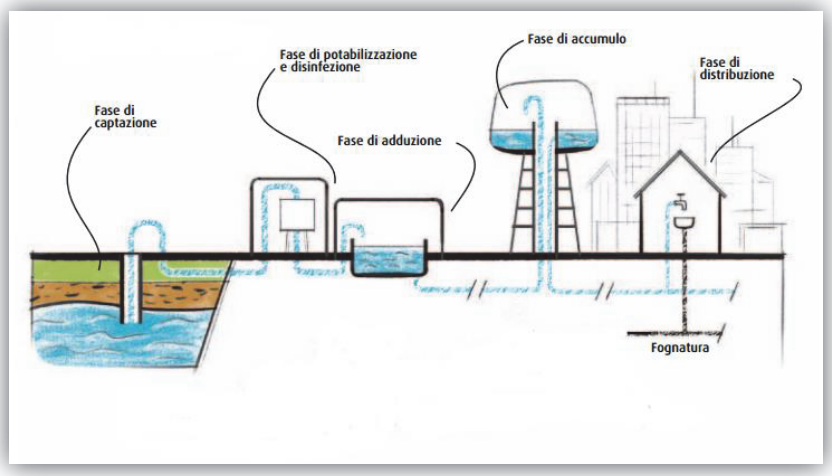
Introduced by the European Commission in 2015, WSPs' aim is to systematically guarantee higienic safety in drinking water systems, quality of distributed water and consumers' health protection, through a comprehensive risk assessment and risk management approach that encompasses all steps in water supply, from catchment to consumer.
The main structure for the implementation of WSPs is defined in a number of guidelines, developed both at national and internation level; nevertheless, the implementation of Water Safety Plans in small systems can be difficult for the following reasons: presence of many production centers with different staff, information spread through many Company's functions, lack of omogeneus evaluation criteria.

In this framework, SMAT Research Center started a project with the aim of defyning an operational tool for risk assessement, based on homoegeus criteria. This will provide a scientific basis for risk assessment and allow comparison of results and integration with other tools currently in use within the company.
For each water supply steps, risk assessment models (checklist) have been created; a list of all possible events, probability classes, gravity leves and, at the end, possible existing control measures, together with efficiency levels, have been defined for every checklist. Initial and final risks are automatically calculated after the checklist has been filled by the operator.
The Water Safety Plan model was tested on three pilot municipalities. The test result is an homogenous evaluation, that allows to define priorities for technical intervention at company level.
Next step will be to complete missing checklists and to draw Water Safety Plans. Priority will be given to those municipalities that presented the highest number of anomalies in past water quality surveys.



"The Water Safety Plan model was tested on three pilot municipalities. The test result is an homogenous evaluation, that allows to define priorities for technical intervention at company level"

RADIOACTIVITY IN WATER IN THE AREA OF THE METROPOLITAN CITY OF TURIN

Analysis/Quality

STATUS
Ongoing

STARTING DATE
July 2016

DURATION
18 months

FUNDING
No

SUPERVISOR
ARPA Piemonte

Drinking water can contain natural radioactive substances due to geological phenomena or irradation in the atmosphere. The possible presence of artificial radionuclides could be related to industrial processes or accidental events. Since radioactivity can be harmful to human health, regardless of its origin, the presence of radioactive substances in drinking water should not be neglected and the recent Decree of Law 28/2016 regulates radiometric controls on water intended for human consumption. The decree requires to monitor three indicators (indicative dose through total alpha and beta activity, tritium activity concentration and radon activity concentration). Sampling criteria should be compliant with a predefined monitoring programme based on the probability that parameters' thresholds are excedeed.

The project, started by SMAT with ARPA Piemonte supervision on procedures, is aimed at mapping the distribution of radionuclides concentration in water in the area of the Metropolitan City of Turin, in order to estimate the committed effective dose taken by the population.
During the first phase of the project, the measurement methodology, based on liquid scintillation counting, has been set up and optimized for very low level counting.
Subsequently, radioactivity data will be elaborated and integrated with context information concerning natural radionuclides' geogenic potential and the presence of possible contamination sources in the catchment area. This analysis will feed the set of preliminary evaluations, which will form the basis for the elaboration of a monitoring program to control environmental radioactivity in the area.

"The project is aimed at verifying the human health requirements for the potential presence of radioactive substances in drinking water"

Cod: LRC_AC_2016_21

INNOVATIVE TECHNOLOGIES FOR WATER PIPE CLEANING

Water networks

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

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

In this context, in June 2016, a new technology based on the use of a simple mixture made of water and ice was applied to the distribution network of Avigliana. The case study demonstrated good effectiveness in cleaning aqueduct pipes. About 250 kg of solid substances were actually removed by an operation which required to shut down the duct for only a few hours. Furthermore, it was possible to reactivate the pipe just minutes after the conclusion of the operation.
Other alternative approaches will be tested in order to define the best mode of intervention for pipeline cleaning depending on different specific conditions.

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

MATHEMATICAL MODEL OF TURIN WATER DISTRIBUTION SYSTEM

Water networks

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

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

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

One of the first expected results is the availability of some simulated physical quantities, like the spatial distribution of mean, minimum and maximum pressure along the network. A systematic and rational approach to the data used for the formulation and calibration of the model is a pivotal prerequisite for the project development.

During the first year of reasearch, we collected and analyzed all the data required for the model formulation. The next activities will include the calibration of the model and its implementation within the SCADA system.

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

AN INNOVATIVE AND INTEGRATED APPROACH IN WATER LOSS MANAGEMENT

Water networks

STATUS
Ongoing

STARTING DATE
September 2016

DURATION
24 months

FUNDING
No

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

The first application envisages the consolidation of a methodology for the analysis of water distribution systems, the identification of district boundaries in the distribution network and the use of data from flow meters which employ SCADA as a data collection system. The most innovative aspect of this approach will be the realization of an “automatic intelligent agent” able to analyze the measurements and identify the presence of anomalies.

The second line of research concerns the construction of a platform able to provide the daily probability of occurrence of a breakage event in the water distribution network. Moreover, the platform will indicate the position of the breakage, in order to enable intervention crews to fix it as fast as possible. The platform will gather incoming data from a set of hydrophone stations, characterized by low cost and reduced energy consumption, continuously surveying noises within water pipes.

The third application aims at the implementation of algorithms derived from a field of network science called "Community Detection". The objective of Community Detection is to detect communities inside complex networks. The purpose of this application is to provide the operator of a distribution network an easy-to-use tool that automatically suggests district boundaries to subdivide the network.

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

SMART DISINFECTION APPLIED TO DRINKING WATER DISTRIBUTION SYSTEM

Supervision

STATUS
Ongoing

STARTING DATE
December 2014

DURATION
36 months

FUNDING
No

PARTNERS
Hera, Iren

The main purpose of the project is to optimize the control of chlorine dynamics in the distribution network, therefore improving the chemical, microbiological and organoleptic characteristics of distributed water. During normal service, the system will allow to reduce chlorine concentration in the distribution network while still guaranteeing the minimum required concentration that ensures proper water disinfection. On the contrary, in case of accidental and/or intentional events of contamination, it will be possible to prevent the distribution of water by rapid identification of the potentially involved areas. In addition, data will be promptly made available to the public, which will increase consumer confidence in water quality.

The first part of the project was dedicated to the study, design and implementation of the monitoring network of chlorine meters. During the subsequent step, calibration of the numerical model of drinking water quality was carried out, using data deriving from the meters already connected to the remote platform. The final phase will have two objectives: the development of an automated warning system based on the identification of anomalies arising from the comparison of the measured data with those provided by the numerical modeling and the implementation of a graphical user interface aimed at visualizing, with the support of satellite images, average values of the measured parameters modeled on the territory.

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

MEMBRANES FOR CHROMIUM VI REMOVAL

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Heavy metals can be found in potentially dangerous concentration at the inlet of drinking water production plants. Their presence is mainly due to agricultural, industrial, mining and transport activities. Sometimes, pollutants can also be natural. The World Health Organization (WHO) has set the guideline value for Chromium at 50 µg/l, but this value could be decreased in the future.
In this framework, SMAT has started a project in collaboration with the Polytechnic University of Turin, in order to test the efficiency of membranes in chromium removal processes. These devices usually have greater efficiency than traditional methods (coagulation-sedimentation processes, softening with soda and line, ionic exchange resins) and do not need to be controlled (they can also be installed in remote zones).

Aim of the project is to assess commercial membranes' performances in order to find the best compromise between removal efficiency and durability, to assess efficiency at lab-scale by comparison between performances on different waters and, finally, to build a pilot plant. Simultaneously, high performance membranes will be designed in order to overcome critical issues that were found in commercially available products.
Two types of membranes have been tested to date; they showed very good efficiency on all tested samples. A protocol for the production of ultrafiltration membranes has been defined and validated. With few modification, the same protocol could find future additional applications inthe production of nanofiltration membranes.
The installation of the pilot plant is currently in progress.

"The first experiments have given good results in terms of chromium removal efficiency; the best compromise between membrane durability and permeability is still to be found"

HYDRODYNAMIC CAVITATION

Treatment

STATUS
Ongoing

STARTING DATE
November 2015

DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Hydrodynamic cavitation describes the process of vaporisation, bubble generation and bubble implosion which occurs in a flowing liquid as a result of a decrease and subsequent increase in local pressure. Cavitation can only occur if the local pressure declines to some point below the saturated vapor pressure of the liquid and then recovers above the vapor pressure. The process of bubble generation and the subsequent growth and collapse of cavitation bubbles result in very high energy densities and in very high local temperatures (up to thousands of ˚C) and local pressures (tens of atmospheres) at the surface of the bubbles for a very short time, without affecting the overall characteristics of the liquid bulk. The extreme conditions of cavitation can help in water purification, breaking down pollutants and organic molecules.

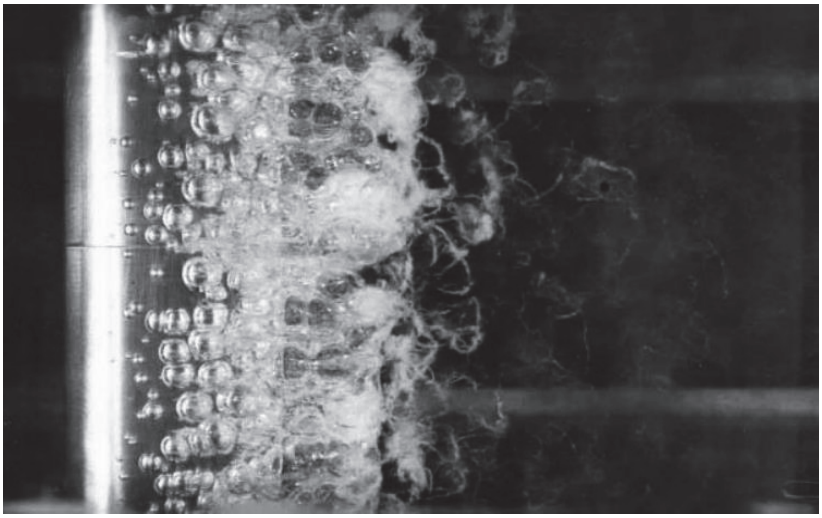
The main goal of this research project is the design, realization and optimization of innovative prototypes of reactors useful for the exploitation of the hydrodynamic cavitation phenomenon for water disinfection.

To date, different prototypes have been developed, mounted on a pilot plant and monitored for the overall evaluation of the operative variables and the process efficacy.

Specific analytical methods were optimized to test prototypes and operational condition efficacy using methylene blue.

In parallel, we have designed the first set of experiments to evaluate the effect of cavitation on untreated surface water with microbiological contamination. Specifically, environmental and faecal microorganisms will be the targets of the analysis.

Future steps will deeply evaluate the water disinfection efficacy of the cavitation phenomenon alone or in combination with other treatment techniques.



"The extreme temperature and pressure conditions of hydrodynamic cavitation can help in water purification, breaking down pollutants and organic molecules "

SLUDGES

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
18 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Sludge disposal represents one of the highest expenses for waste water treatment plants. Optimization of sludge treatment processes, especially anaerobic digestion, would be highly desirable to increase biogas production (and consequent co-generation of electrical and thermal energy) and to reduce the amount of solid digestion products and their deriving drying and disposal costs. From this standpoint, SMAT and the Polytechnic University of Turin joined their efforts in order to identify more efficient plant and process solutions to be applied in the sludge treatment line at the waste water treatment plant in Castiglione Torinese.

During a previous project, conducing lab scale batch digestion tests (5 litres) we studied hydrolysis rates and consequent biogas productivity increases after sludge low-temperature treatment (70, 80 and 90°C) for different treatment times (up to 3 hours) and with a range of base concentrations (sodium hydroxide, calcium hydroxide). Particular attention was dedicated to the identification of the optimal conditions for the thermo-chemical pre-treatment in order to maximize biogas productivity and organic substance removal.

The aim of this project is to study biogas productivity in a larger pilot scale (300 litre anaerobic digestor) and with semi-continuous feeding of surplus sludges exposed to the optimal treatment conditions identified in the previous experimental tests.

In particular, the first part of the project activities was devoted to the start-up and optimization of the pilot digestor and of a reactor for thermo-chemical treatment of surplus sludges. The following experimental phase was dedicated to the determination of biogas productivity of untreated sludge, which will represent the reference case for the evaluation of pretreatment performances.

"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

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

The use of numerical simulation models is becoming more and more important in the design and management of wastewater treatment in order to correctly size plants and identify the most appropriate control logics. This allows to optimize the purification process efficiency and to appropriately regulate the operative conditions related to the variability of the pollution load input.

The project envisages the use of the GPS-X software based on the ASM model developed by IAWPRC (Henze 1987, Gujer et al., 1999) for modeling the water line of the SMAT wastewater treatment plant located in Castiglione Torinese. We collected the plant design information, elaborated the flow and analytical data available for several years and carried out surveys in the field and laboratory determinations in order to obtain an assessment of the parameters that were not measured (ex. recirculation rates of sludge and aerated mixture).

Laboratory tests were conducted to determine the components of the incoming COD, using both chemical-physical and respirometric techniques. The chemical-physical and operational parameters of the primary treatment processes, secondary denitrification with active sludge and secondary sedimentation were detailed thanks to a one month long sampling campaign on a module of the plant.

Based on these results, the water line model was realized both in steady and dynamic conditions, and the calibration procedure was launched by comparing the experimental data obtained from laboratory analyses and the online measures. During the second year of activity we will proceed to the model optimization and to verify some anomalies detected between the field measurements and the laboratory analyses, in particular for the parameter “ammoniacal nitrogen”.

“The use of numerical simulation models is becoming more and more important in the design and management of wastewater treatment in order to correctly size plants and identify the most appropriate control logics”

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

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

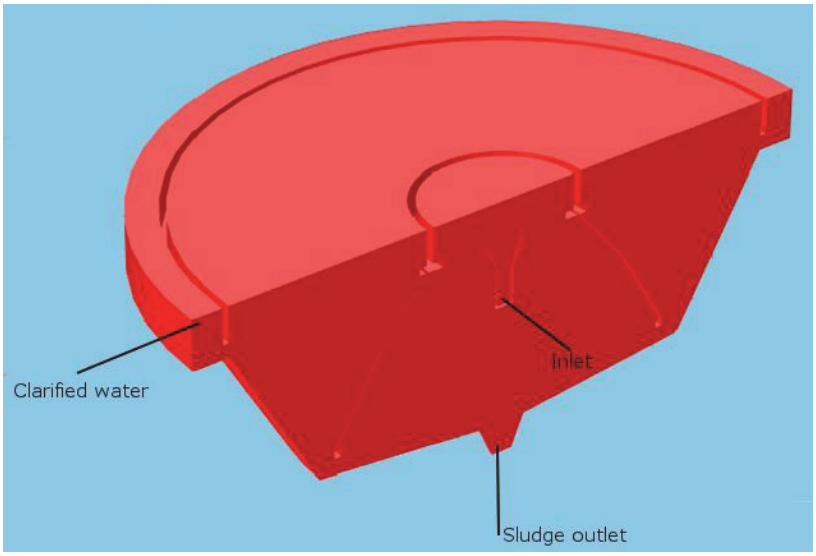
DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

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

The goal of this research project, which is proceeding in collaboration among the Polytechnic University of Turin, the SMAT Research Centre and the operative line of the river Po drinking water treatment plant, is to develop a mathematical model of the coagulation-flocculation unit of the PO3 operative line.



Specifically, modelling will include an hydraulic component, which is a fundamental element that ensures the efficiency of a treatment plant, and a physical-chemical process modelling.

During the initial phase, all the available process data (pH, turbidity, temperature, flows, reagent dosing) were collected, verified and analyzed, and the first model calibration is currently being carried out. This kind of multidisciplinary approach will bring to a forecast of the turbidity downstream of the coagulation-flocculation unit, and to the evaluation of the potential optimization of the process in order to improve its management.

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

ALGAEBIOUP

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Biogas, produced by anaerobic digestion of sewage sludges, is a gas mixture mainly composed of methane (around 60%), carbon dioxide (around 40 %), hydrogen sulfide traces and other impurities (i.e. siloxanes).
A valuable alternative to traditional biogas recovery through cogeneration of electric and thermal power is the so called biomethanation. It consists of the process of biogas purification through the removal of carbon dioxide and other impurities, aimed at producing *quasi* pure methane that, if meeting the required quality standards, could be introduced into the natural gas distribution grid and used elsewhere, for example for energetic purposes (gas power plants) or transportation (gas powered vehicles).
The most popular technologies for biomethanation are generally based on membrane separation or on CO2 absorption in pressurized water.

The aim of this project is to study and test algae cultivation as an innovative biomethanation technology.
Indeed, microalgae are photosynthetic organisms that use solar energy to absorb CO2 (thus removing it from biogas) which is then transformed into new algae biomass. In our case biogas, likely after a pre-treatment step, would be the source of CO2 for algae. The products of this process would be two: biomethane, originated from biogas purification, and algae biomass witch can be used for different purposes (animal feeding, cosmetics, nutraceutics, etc…).
The first part of the project was devoted to the study, trough lab tests, of the most suitable algae species for the specific purpose of the project, that is those showing the best adaptation to the available water-based growth medium and the optimal growth rate and carbon dioxide removal rate.
The second part of the project will be aimed at algae cultivation tests inside an innovative and low-cost photobioreactor for the optimization of biomass and biomethane productivity. We will also study the mechanisms of oxygen (produced by algae during photosynthesis) removal. Finally pilot scale experimental results will be evaluated in terms of biomethane quality.

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

WATER TREATMENT THROUGH PHOTOCATALYSIS AND SOLAR ENERGY

Treatment

STATUS
Ongoing

STARTING DATE
January 2016

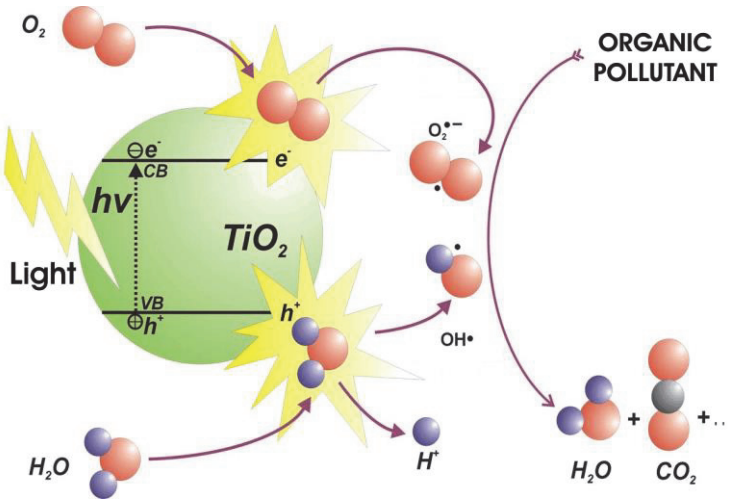
DURATION
24 months

FUNDING
No

PARTNERS
Polytechnic University of Turin

Advanced Oxidation Processes (AOP) are currently attracting growing interest in the scientific community thanks to their efficiency in the treatment of emerging contaminants that are not always completely removed by traditional methods. The aim of this project is the evaluation of photocatalysis performances in water treatment, particularly through the use of solar irradiation. Photocatalysis occurs thanks to a solid phase catalyst (in this case titanium dioxide) activated by light, and can be used to promote the degradation of different types of pollutants found in water until mineralization.

In the first step of the project, lab scale tests of photocatalysis with titanium dioxide have been carried out. The variables that were taken into account were: catalyst medium in the suspended and supported form, different operative conditions in terms of exposition, catalyst concentration, exposition time and radiation intensity. The effect was investigated on microbiological and chemical pollutants.
These activities allowed us to confirm the treatment efficiency applied to aqueous matrixes and to preliminarily find operational conditions for the next tests on pilot scale. An experimental pilot system has indeed been designed and is currently being built. The system will allow to perform dynamic tests on continuous flows. The prototype was designed for optimal exploitation of solar irradiation during the field tests that will be performed in the second phase of the project.



"The aim of this project is to evaluate photocatalysis performance in water treatment, particularly through the use of solar irradiation"

ASSESSMENT OF GRANULAR ACTIVATED CARBON'S ADSORBING CAPACITY

Treatment

STATUS
Ongoing

STARTING DATE
November 2016

DURATION
24 months

FUNDING
No

PARTNERS
//

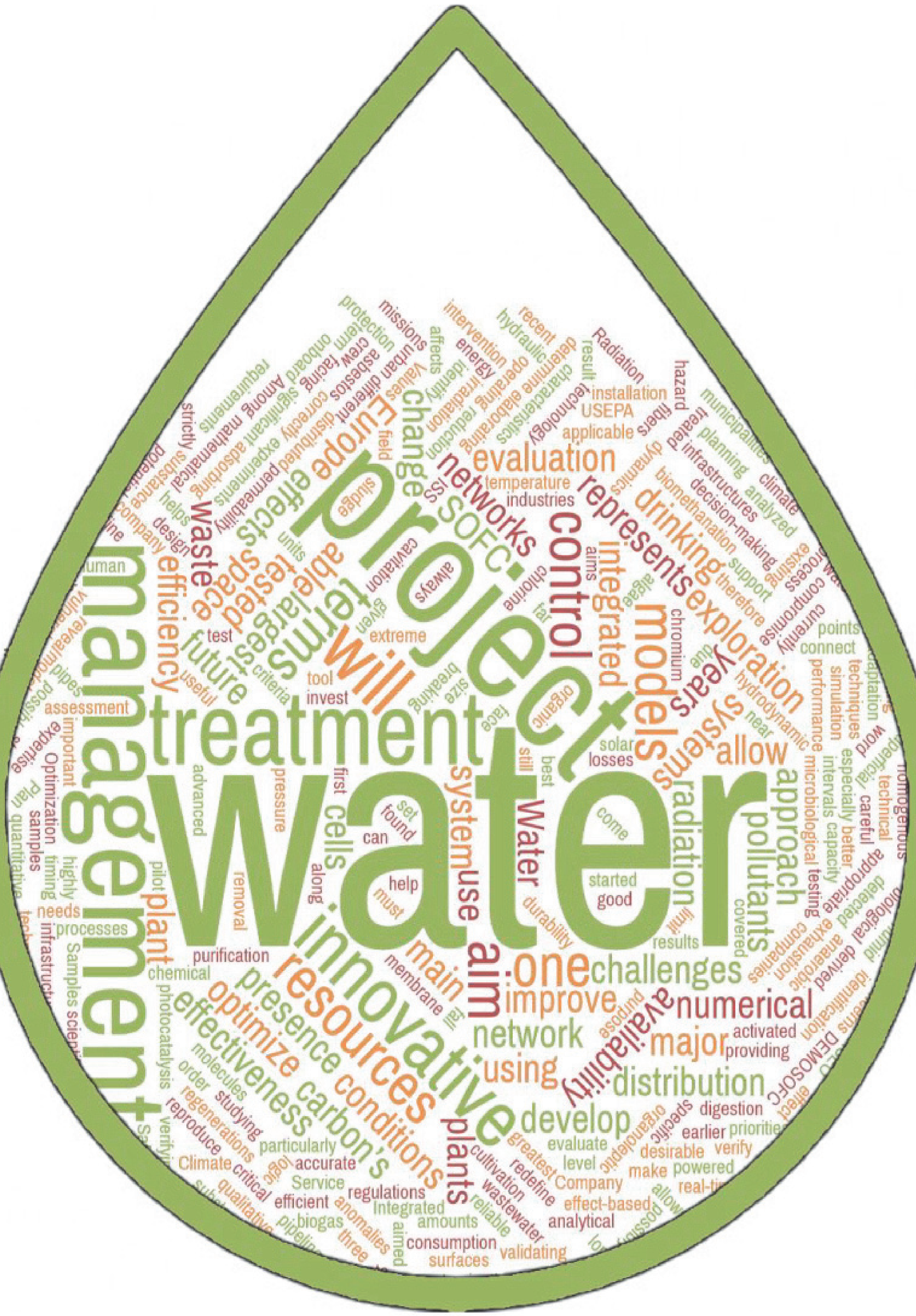
The purifying properties of charcoal have been well known since ancient times. Its first application for drinking water dates back to 1800, when it was used in England to remove odours from water. The assessment of activated carbon adsorbing capacity is based on specific indicators like benzene, molasses,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

The first stage of this project was focused on time series analysis of quality data and hydraulic parameters from treatment plants. The so-called "loadings" are currently being elaborated for the most common micro-pollutants, taking into account the co-presence of other pollutants and the effect of different matrices.

The accurate and site-specific assessment of activated carbon adsorbing capacity will allow to optimize intervals between regenerations considering molecules already subject to regulation in water intended for human consumption.

This study will also allow to delineate the criteria to define carbon exhaustion for pollutants currently not covered by European regulations (EU Drinking Water Directive) by comparison with other international regulating authorities (WHO, Drinking Water Guidelines; USEPA, EFSA,etc.).

"The accurate and site-specific assessment of activated carbon adsorbing capacity will allow to optimize intervals between regenerations and delineate the criteria to define carbon exhaustion for pollutants currently not covered by applicable regulations"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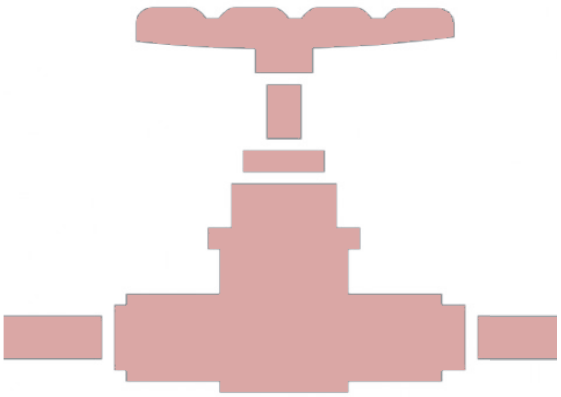

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CNR-IRSA
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