demEAUmed

INNOVATIVE TECHNOLOGIES FOR WATER EFFICIENT MANAGEMENT IN THE TOURISTIC FACILITIES

WWW.DEMEAUMED.EU

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CONTENTS

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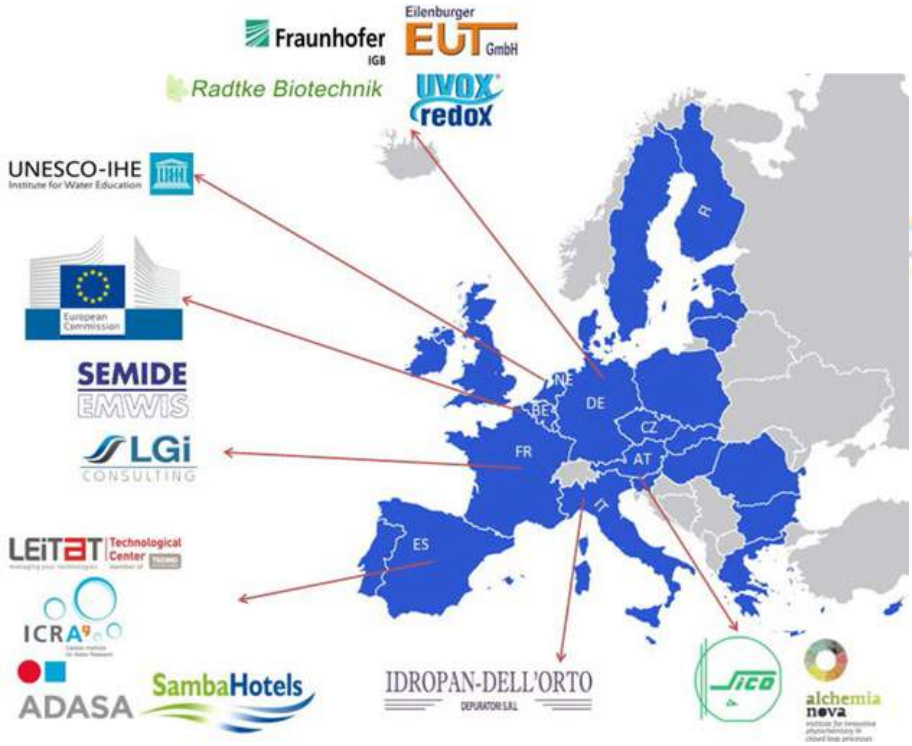


WHAT IS DEMEAUMED?

demEAUmed is a water innovation project co-funded by the European Union under the 7th Framework Program for a period of 42 months (2014-2017). The project demonstrates and promotes innovative technologies for an optimal and safe closed water cycle in Euro-Mediterranean tourist facilities.

The project has succeeded in demonstrating the reduction of the fresh water consumption in hotel installations and the establishment of green and recreational areas by using alternative water sources, such as treated groundwater, treated rainwater or the reuse of treated grey water and/ or wastewater within a resort.

Eight different categories of innovative treatment technologies together with a monitoring control tool and a decision support system are integrated and demonstrated in real-life situation at Samba Hotel located near Barcelona, Spain:

a 172 NM UV treatment

b Electrochemical ozonation

c Electrocoagulation-flotation technology (EC-EFl)

d Plimmer technology

e Smart air MBR

f Solar photo-electro-Fenton process (SPEF)

g UVOX technology and

h vertECO: constructed vertical ecosystem

These technologies provide cost-effective solutions for a safe reuse of treated waste water, and they can be used individually or in a package.

DEMEAUMED POLICY BRIEF:

WATER REUSE LEGISLATIONS IN THE MEDITERRANEAN TOURIST FACILITIES

"Every year in Europe more than 40,000 million m3 of wastewater are treated, but only 964 million m3 (2.4%) of this treated wastewater is reused, less than 0.5% of annual European freshwater withdrawals" (European Commission)

The problem of water and tourism in Mediterranean areas

Despite Europe is, on average, being classified as non-water-stressed, water scarcity conditions created by population growth, urbanism and tourism have influenced highly populated areas in the Mediterranean countries in recent years.

Two issues influence the Mediterranean countries:

- Water resources are limited and unequally distributed in space and time.
- The Mediterranean is one of the world's top tourist destinations, attracting an increasing number of people because of good weather conditions and stunning natural scenery.

Tourism activities increase pressures on water resources, and this is exacerbated in case of higher water stress and lower precipitation. A tourist consumes 3 to 4 times more water per day than a permanent resident (who consumes between 100 and 200 litres per person per day) . Moreover, tourism-related water consumption is not limited to food, drink and personal hygiene, but also includes consumption related to other activities such as swimming pools, spas, golf, etc.

In summary, if the constant increase of tourism rate in the Mediterranean region is considered, regulations should be promoted for the use of alternative water sources (e.g. reclaimed water) in order to reduce the pressures and lessen the environmental impacts related to water consumption in tourist facilities.

EU legislation on water reuse

At the European level, no legal instruments concerning water reuse are available. However, few initiatives have been recently developed in order to flag the issue of harmonized regulations for water reuse in Europe.

Some European countries have developed their own regulations, defining the acceptable uses for treated wastewater. Examples of countries with existing regulation or guidelines at the national level for water reuse applications are: Cyprus, France, Greece, Italy, Portugal, and Spain.

The lack of harmonization in water reuse regulations among EU countries makes the comparison between different previously defined regulations or guidelines difficult. Currently, each member state develops its own regulation on water reuse, by establishing the water uses that are permitted, the water quality parameters to be monitored and the limit values for water quality. Nowadays, the accepted reuse possibilities of treated waste-water in the different member states are the following: irrigation (including: green areas, private gardens, golf courses and crops or trees not consumed by humans), cleaning (streets or some industrial uses), fire hydrants, aquaculture, supply to sanitary appliances, cooling towers and evaporative condensers, aquifer recharge, silviculture or environmental uses (maintenance of wetlands).

Water reuse in Mediterranean tourist facilities

Most Mediterranean tourist facilities consume large amount of water, due to high water consumption for swimming pools or golf course, among others. Since no regulation specifies the waste-water treatment procedure to be applied in tourist facilities, greywater and wastewater/blackwater are usually collected without separation and subsequently treated onsite or in an urban wastewater treatment plant.

Some Mediterranean resorts are implementing eco-friendly practices such as water saving devices in bathrooms and internal treatment and reuse of some effluents (e.g. water from shower and sink for supply to sanitary appliances) in limited applications, such as garden irrigation. However, these are not necessarily part of a comprehensive strategy of the sector.

Recommendations following demEAUmed project

Existing barriers to reuse of wastewater and greywater have to be solved in order to reduce the environmental impact of current water consumption in Euro-Mediterranean areas and diversify water sources.

The main barriers and improvement measures detected during the demEAUmed project are the following:

	BARRIER	IMPROVEMENTMEASURES
Social	Low public/governmental awareness and acceptance on water reuse	Awareness campaigns to explain environmental and economic benefits of water reuse practices
		Involvement of all the stakeholders at early stages of water reuse projects
	Consumer's lack of confidence in the health and environmental safety	Public information programmes about water security of urban water cycle management
Economic	Water reuseeconomicviability	Design of specific water pricing policies
		Provision of adequate incentives (administrative, institutional and financing) to develop water reuse projects
Technological	Low efficiency, reliability or knowledge of water reclamation treatment processes	Implement small-scale decentralized water reclamation treatment processes/plants
		Promote funding programmes for water reuse technology development
Policy	Lack of harmonization of water reuse legislation at European level	Develop harmonized and adequate water reuse standards at the European level, including the establishment of water quality parameters to be monitored and limit values
	Disregards local conditions and feasibility conditions with respect to the implementation of water reuse standards	Develop a flexible, legally-binding framework on water reuse at the European level

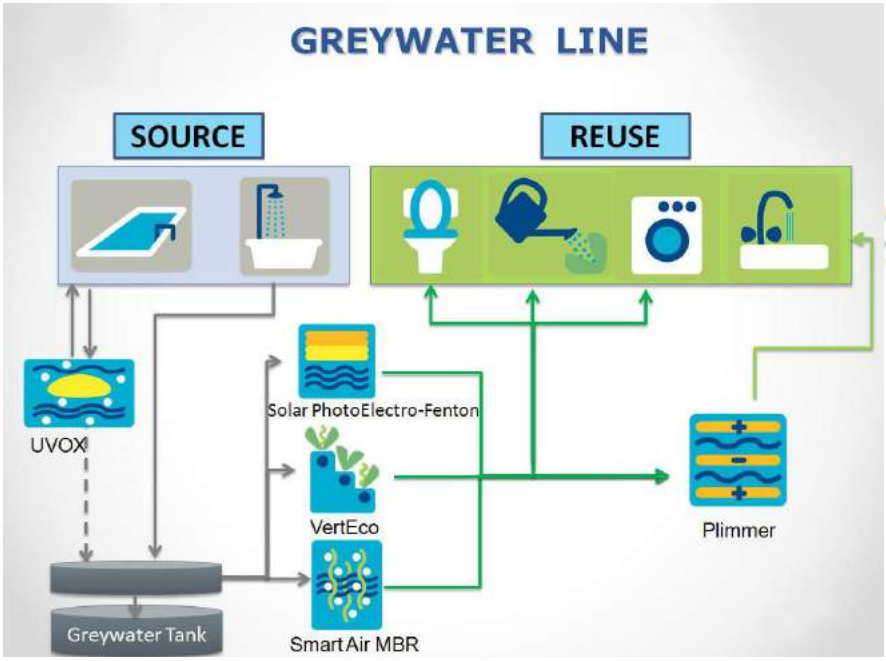
SAMBA HOTEL -DEMONSTRATION SITE

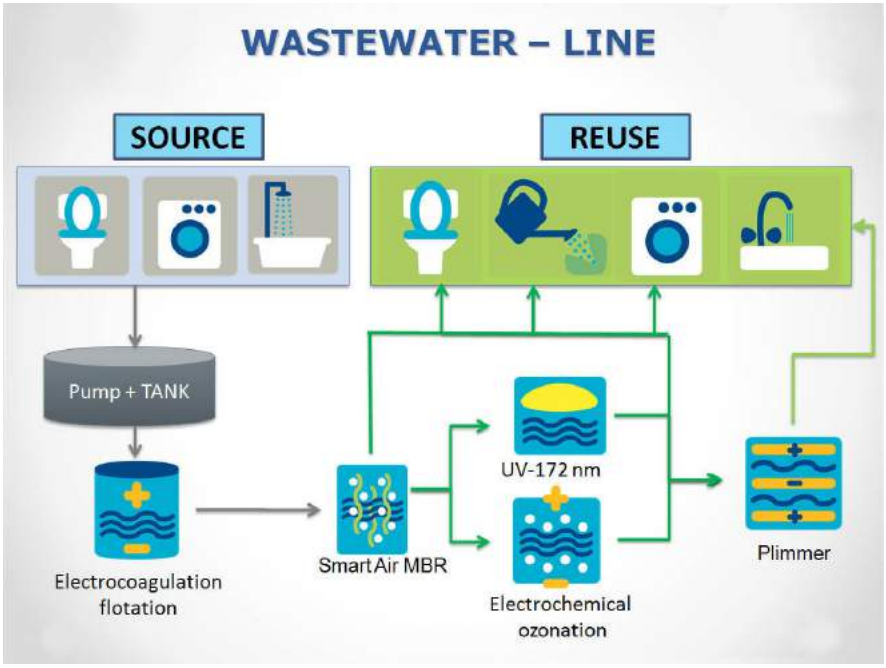
The demonstration site of demEAUmed is Hotel Samba; a 3-star hotel chain situated in Lloret del Mar and Blanes near Barcelona. It is a large resort with 441 air conditioned rooms, green areas and exterior pools, conference rooms, a bar and a restaurant. It is certified by EMAS and ISO 14001.

The eight innovative demEAUmed technologies, after tests at pre-demonstration level, have been scaled-up, placed at the demonstration site and are being run in real conditions with two main lines for greywater and wastewater treatment.

DEMEAUMED SOLUTIONS

One of the achievements of demEAUmed project is comparing these technologies in terms of efficiency, cost and environmental impacts in order to provide indications of their applicability in real case scenarios. They have been demonstrated in two different water cycles: greywater and wastewater (combining greywater with black water from the toilets and kitchen water).



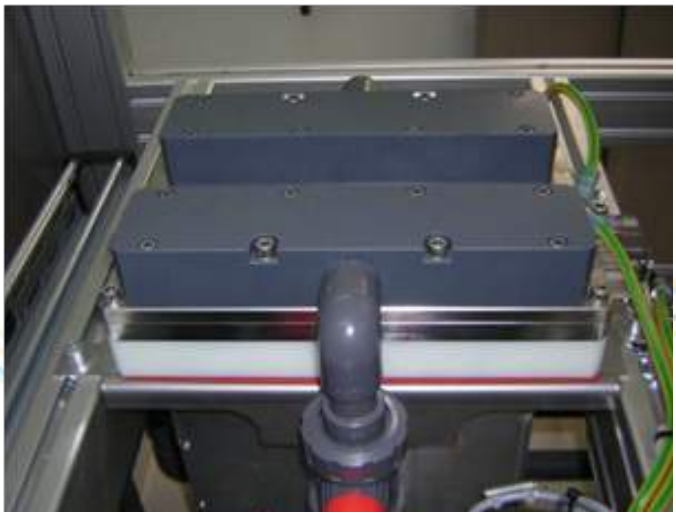


172 NM UV TREATMENT

DESCRIPTION

In this Advanced Oxidation Process (AOP) hydroxyl-radicals are used to degrade complex and persistent organic molecules which present in the water as contamination.

172nm UV directly attacks different pollutants and it's able to break down resilient and harmful molecules.



APPLICABILITY

The 172nm UV technology can treat every type of waste water as long as the water is free from suspended solids and/or sludge.

In demEAUmed, targets for 172nmUV are:

- Cleaning agent residuals and pesticides,
- Different pharmacological substances,
- Persistent, non-biodegradable organic pollutants.

The performance depends on the degree of the pollution in the water.For demEAUmed, the water in the operational tank is treated and continuously analysed by a TOC analyser until the desired quality is reached.

ADVANTAGES OF 172NM UV TECHNOLOGY:

- Automatic operation,
- Chemical free process – no need to add hydrogen peroxide, ozone or catalysts,
- Adjustable treatment capacity,
- No gas exhaust, no noticeable smell,
- Disinfection of the treated water as a side-effect,
- Independent from the salinity or hardness of the stream,
- Independent from UV-absorbance of the feed water.

ADDITIONAL VALUE

The process runs until the desired output quality is reached.

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ELECTROCHEMICAL OZONATION TECHNOLOGY

DESCRIPTION

The Electrochemical Ozonation technology uses electrodes coated with boron doped diamond which produce an oxygen-ozone mixture with higher ozone concentration than can be achieved with conventional gas discharge ozone generators. The ozone is produced in the wastewater and therefore directly and perfectly dissolved in it. Less apparatus is involved when compared with conventional ozone generators. And there is no need to provide an oxygen feed line. Differing concentrations of pollutants pose no problem as integrated measuring/control system makes the system energy-efficient and ensures continuous operation.

APPLICABILITY

The technology holds potential as polishing treatment for small to medium scale installations in view of achieving drinking water quality of the treated water. It removes emergent and priority pollutants even at trace levels and disinfect the water. The technology is in use today to remove organic substances from ultra-pure water and to directly treat recalcitrant or toxic industrial effluents.

ADVANTAGES

- No oxygen feed needed
- Automatic operation
- Chemical free process – no need to add hydrogen peroxide, ozone or catalysts
- Adjustable treatment capacity
- Adjustable treatment intensity (saving energy)
- Disinfection of the treated water as a side-effect
- Independent of UV-absorbance of the feed water

ADDITIONAL VALUE

- Low running costs.
- In pre-treated domestic wastewater the system oxidizes > 90% of trace organic pollutants with an electrical energy input of less than 1 kWh/m³.

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ELECTROCOAGULATION-FLOTATION TECHNOLOGY

DESCRIPTION

Electrocoagulation-flotation (EC-EFI) is an electrochemical process used as alternative to conventional coagulation/flotation processes. In this advanced technology, coagulum agents are in situ generated through electrochemical oxidation of sacrificial metallic plates (e.g. iron or aluminium) used as anodic material (Equation 1). Obtained Fe(II)/Fe(III) (Equation 2) or Al(III) precipitate with hydroxide ions (Equations 3 and 4) generating coagulum particles which destabilizes and adsorb water pollutants by surface complexation or electrostatic attraction12. Pollutants will be removed by sedimentation or electroflotation owing to bubbles of hydrogen gas generated at cathode surface (Equation 5).

$$Fe(s) \rightarrow Fe2+(aq) + 2e- \quad (1)$$
$$Fe2+(aq) \rightarrow Fe3+(aq) + 1e- \quad (2)$$
$$Fe2+ + 2OH-(aq) \rightarrow Fe(OH)2(s) \quad (3)$$
$$Fe3+(aq) + 3OH-(aq) \rightarrow Fe(OH)3(s) \quad (4)$$
$$2H2O(l) + 2e- \rightarrow H2(g) + 2OH-(aq) \quad (5)$$

The innovation of EC-EFI is that polarity inversion is performed several times per minute in order to combine the electrocoagulation process with flotation due to hydrogen and oxygen generation in the electrodes (Equation 6 and 7):

$$H2O(l) \rightarrow \tfrac{1}{2}\, O2(g) + 2H+(aq) + 2e- \quad (6)$$
$$H2O(l) + e- \rightarrow \tfrac{1}{2}\, H2(g) + OH-(aq) \quad (7)$$

APPLICABILITY

Electrocoagulation-flotation process is used as primary treatments for wastewater treatment in order to remove suspended solids and oils & fats, and slightly reduce the turbidity and the organic matter content.

If needed, it could be also applied for kitchen effluent treatment or for other effluents such as those industrial ones that have high suspended solids, metal and organic matter content.

ADVANTAGES

- Compact system
- Minimization of the use of chemicals externally added.
- Possibility of water reuse
- Removal of toxic/recalcitrant emergent pollutants.
- Possibility to be fed by solar PV panels.

ADDITIONAL VALUE

- Generation of in-situ coagulants that avoid the use of external chemicals.
- It could be feed by solar light.

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PLIMMER® TECHNOLOGY

DESCRIPTION

Plimmer® is a non-Membrane technology which treats ground/surface water to drinkable standards.

It requires very low pressure and results in low power consumption. It reduces water wastage since water is not pushed into a membrane under high pressure.

This technology has 12 patents in terms of number of electrodes, coating on electrodes and electronics required to handle the process and no chemicals are required for treating water. Electrodes require just 1.6 V charge to operate – providing an option to run on alternative energy sources (e.g. solar).

APPLICABILITY

Plimmer® system provides a largely accessible method of desalination water in domestic, commercial and industrial contexts. It perfectly removes substances that dissociate in ions which present in raw water.

Common target pollutant/substances are:

- Temporary hardness
- Permanent hardness
- Sodium chloride and Sodium sulfate
- Nitrates and Nitrites
- Ammonia
- Metals; such as Fe, Mg (if they present as ions)
- Arsenic (if present as ion)
- Hexa-valentchromium

ADVANTAGES

Eco-friendly treatment process: Citric Acid is an organic acid extracted from lemon trees which also provides the electrodes a longer useful life.

- Low Carbon Footprint: It ensures 30% less energy required to desalinate water.
- Improved Water Footprint: It recovers 80% - 90% of fresh water.
- Automatic Operation.

COSTS ISSUES

Capital expenditure is similar to a standard Reverse Osmosis unit. It is very low where the Return on Investment (ROI) is expected in less than a year.

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SMART AIR MBR® TECHNOLOGY

Membrane bioreactors (MBR) are a consolidated technology for biological treatment of industrial and municipal wastewater. They guarantee high water quality which has led to a growing demand for this technology, especially in areas where water is scarce and its re-use must be prioritised.

Smart Air MBR® is the only product on the market that effectively reduces the energy costs associated with MBR air-scour according to the online monitoring of permeability, and places it in an excellent competitive position.

APPLICABILITY

The technology is innovative compared to existing technologies, which do not take into account the status of membrane fouling in real-time to control the process. It is suitable for the treatment of:

- Greywater; e.g. shower water and laundry water, and
- Domestic/industrial wastewater.

Target pollutants are:

- Biodegradable organic matter,
- Nitrogen,
- Micro-pollutants such as pharmaceuticals and
- Micro-biological charge.

The Smart Air MBR® technology, according to parameters of Spanish water reuse legislations, could be potentially used for: •

Toilet flushing,

- Golf irrigation,
- Private garden irrigation and
- Groundwater recharge.

ADVANTAGES OF MBR® TECHNOLOGY

- Reductions down to 20% of the air scour required to clean the membranes.
- Savings up to 35% of the cost of membrane aeration.

- Reliable control of membrane fouling parameters evolution together with biological process parameters.
- Optimisation on the frequency of maintenance cleanings.
- Stabilisation of the biological nutrient removal, maintaining or improving the quality of the effluent, in comparison with existing control systems.
- Extension of membrane life.
- Adaptation to any membrane configuration.

ADDITIONAL VALUE

It only requires the standard instruments of a conventional MBR (permeate flux and transmembrane pressure), and it does not need any additional equipment other than remote connection and a server. Energy saving and water reuse are guaranteed.

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SOLAR PHOTOELECTRO-FENTON PROCESS

DESCRIPTION

Solar photoelectro-Fenton (SPEF) process is an advanced electrochemical oxidation process (AEOP) that has been developed for the remediation of acidic wastewaters containing hazardous organics. This process is based on the H2O2 generation from the two electron reduction of O2 at a carbonaceous cathode:

$$O_2(g) + 2H^+(aq) + 2e^- \rightarrow H_2O_2(aq) \quad (1)$$

and the addition of a small amount of Fe2+ to the treated solution to produce •OH and Fe3+ from the classical Fenton's reaction:

$$Fe^{2+}(aq) + H_2O_2(aq) \rightarrow Fe^{3+}(aq) + {\bullet}OH(aq) + OH^-(aq) \quad (2)$$

Since Fe2+ can be regenerated from Fe3+ reduction at the cathode and due to solar radiation (solar photo-Fenton process), Eq. 2 can be propagated due to the catalytic behaviour of the Fe3+/Fe2+ system. The most frequently used anodes in the indirect electro-oxidation EF systems are Pt and boron-doped diamond (BDD), being the latter preferable by its higher oxidation power on organic pollutants. If the electrochemical process is carried out in an undivided cell, apart from the electro-Fenton mechanism, organics can also be destroyed by •OH produced at the anode surface from water oxidation (3) in the case of a BDD anode :

$$BDD + H_2O(l) \rightarrow BDD({\bullet}OH) + H^+(aq) + e^- \quad (3)$$

APPLICABILITY

The technology could be applied as tertiary treatment for removing emergent/prior pollutants and disinfecting (swimming pool effluents, greywaters, wastewaters…) as well as primary treatment for recalcitrant and/or toxic industrial effluents (such as pharmaceutical, landfill leachate, etc.).

ADVANTAGES

- Use of solar light as driving-force of the process as well as for feeding the power supply.
- Minimization of the use of chemicals externally added.
- Water disinfection.
- Possibility of water reuse
- Removal of toxic/recalcitrant emergent pollutants.

ADDITIONAL VALUE

- Generation of in-situ oxidants with high oxidant power to mineralize non-selectively organic matter.
- It could be feed by solar light.

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UVOX TECHNOLOGY

DESCRIPTION

The UVOX process combines the disinfecting effect of ultraviolet light with the oxidising effect of ozone and hydroxyl radicals in one single system with one single lamp. UV-Disinfection, Ozonation and the advanced oxidation by means of hydroxyl radicals lead to the inactivation of all pathogens and microorganisms in the water (e.g. bacteria, viruses and algae) and to the oxidation of (micro) pollutants (such as nitrite, cyanide, pesticides, chlorinated hydrocarbons, hydrosulphides, odours, humic substances and pharmaceutical products).

APPLICABILITY

UVOX Systems provide environmentally friendly, healthy and non-residual water treatment for:

- Public swimming pools,
- Private swimming pools,
- Natural pools & swimming ponds,
- Koi & Fish pond, fish hatcheries,
- Aquariums & zoos,
- Drinking water and
- Process water / grey water.

ADVANTAGES OF UVOX TECHNOLOGY:

- UVOX destroys organic compounds and inactivates pathogens and algae up to 99, 99 %.
- It enables reduction of residual chlorine concentration and thus reduces the formation of disinfection by-products (DBP`s) such as mono-, di- and tri- chlorine and THM.
- Lesser usage of chemicals, water and energy reduce costs associated with the application of UVOX system.
- Eliminates unpleasant odours and tastes and provides healthy, residual-free water.

ADDITIONAL VALUE

- Generation of in-situ oxidants with high oxidant power to mineralize non-selectively organic matter.
- It could be feed by solar light.

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VERTECO: CONSTRUCTED VERTICAL ECOSYSTEM

DESCRIPTION

This technology treats grey water through an indoor vertical constructed plant based wetland. The underlying principle is the employment of certain plant species in a special sequence for cleansing of the polluted water, grey water in this case; hence, improving the water quality enabling a reuse of the treated water. The investigated plant species function in symbiosis with rhizosphere specific microorganisms providing intrinsic water cleaning abilities. For the constructed plant based wetland, a vertical set-up was employed combined with a subsurface horizontal flow. An approach with a green wall unit with three meters length employed for a grey water pollution level of tourist facilities revealed already very promising results.

APPLICABILITY

For the treatment of:

- Greywater
- Shower water
- Laundry water

The vertical ecosystem effluent, according to parameters of Spanish legislations, can be used for:

- Toilet flushing
- Golf irrigation
- Private garden irrigation
- Groundwater recharge
- Laundry

VEGETATION

Different species of marshplants (e.g. Typha, Iris), graminoids (Carex, Cyperus) tropical and subtropical plants (e.g. Ficus, Spathiphyllum, Epiprenum)

ADVANTAGES

- Water savings
- Aesthetic value
- Clean air
- Green image
- Visualizing water cycles

ADDITIONAL VALUE

- Comprehensibleness of ecosystem services
- Aesthetic value
- Improve the indoor environment
- Positive effects on well-being

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DEMEAUMED MONITORING CONTROL TOOL

DESCRIPTION

demEAUmed monitoring control tool is a platform to show, control, generate alarms and record the information of the different water values thought the hotel.

The physical architecture is a Power-Line Communication (PLC) network which takes the inputs of the different emitters and manages the generated information where a Reliance licensed system, SCADA/HMI, is used for the visualization.

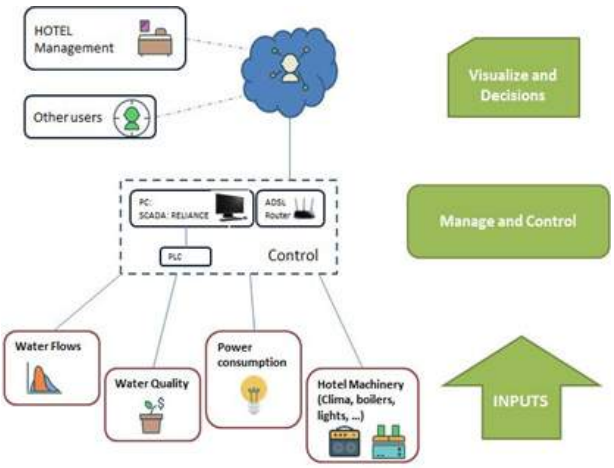
The core of the system is a Control PC with the SCADA software. These industrial SCADA can get the data from technologies directly throw Ethernet connection and from the PLC network.

The PLC network integrates 3 Phoenix Contact PLC, one as a master and the other two for the main water areas of the facility (see the figure below).

The SCADA allows users to connect remotely. It allows displaying windows with real-time visualized data and controlling them, displaying and acknowledging current alarms, displaying historical data, trends and reports as well as displaying historical alarms.

APPLICABILITY

demEAUmed monitoring control tool can be used in facilities that require efficient water management since it is important to know, in real time, the different flows, quality and amounts of water. In addition, the tool can be used to improve and manage other information and values about the hotel heart, such as room/areas temperature, electrical consumption, machine information (pumps pressure, flow, boilers temperature, etc.)



The tool is applicable for other facilities/sectors such as the urban use in small and remote communities dealing with water shortages and commercial buildings market in specific water stressed areas.

INNOVATION FACTOR

- The use of industrial application for water management in hotels providing information about water quality and consumptions.
- Introducing Big Data in Resorts & Hotel Management to improve efficiency and reduce cost.

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DEMEAUMED DECISION SUPPORT SYSTEM AND MODELLING

DESCRIPTION:

demEAUmed Decision Support System (DSS) defines best water management options in touristic facilities taking into account the considered water treatment solutions. It evaluates different scenarios of water sources, water/wastewater quality, demands and changes in the environmental conditions and to define the best management alternatives for each scenario.

The DSS is composed of three components:

- Water cycle model
- Reuse technologies
- Optimization layer

Once run, the results show the water flows, qualities, and savings. In addition, the environmental, social and economic impacts are also quantified.

This program is web-based and assumes steady state for the hotel that is being modelled. It is programmed in Java and can be used by anyone with an interest in the possible benefits of implementation of an onsite water reuse system in a hotel. If necessary the user can also modify values such as the frequency with which the guests use the various water-using devices to improve model accuracy.

APPLICABILITY

This DSS can be used to model the water management systems of most types of hotels. Accuracy is determined by how specific the data is to the hotel being simulated. This tool can aid hotel managers and water treatment technology companies quantify the following:

- Savings due to water reuse
- Water flows throughout the water management system
- Water qualities of all of the water flows
- Energy use associated with the operation of the treatment systems
- Chemicals needed for treatment

In addition, the DSS can also quantify the degree to which water management systems affect the environment, incur economic costs, and affect the society. Comparisons can also be made between scenarios to determine the optimum technologies.

INNOVATION FACTOR

- Possibility of simulating a diverse array of hotel water management systems in many contexts
- Determination of the quantity and quality of each of the water flows within the hotel
- Estimation of the water savings via water reuse systems
- Estimation of the environmental, socio-economic impacts of water management system configurations.

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Find further information and updates on demEAUmed project and its innovative products on: www.demeaumed.eu

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