MADFORWATER

DevelopMent AnD application of integrated technological and management solutions FOR wasteWATER treatment and efficient reuse in agriculture tailored to the needs of Mediterranean African Countries

www.madforwater.eu

Dear Reader,

welcome to the second newsletter of MADFORWATER, an Horizon 2020 Research and Innovation Action project financed under topic WATER-5c-2015 "Development of water supply and sanitation technology, systems and tools, and/or methodologies" and coordinated by the University of Bologna (Italy). The general goal of MADFORWATER is to develop a set of integrated technological and management solutions to enhance wastewater treatment, treated water reuse for irrigation and water efficiency in agriculture in Egypt, Morocco and Tunisia. MADFORWATER is focusing on municipal, agro-industrial and industrial wastewaters, as well as on the drainage canal waters of the Nile Delta. The development and validation of technologies is combined to the definition of integrated water management strategies, tailored to the local context of selected hydrological basins in Egypt, Morocco and Tunisia.

MADFORWATER, started on June 1 2016, has reached its 24th month of activity. During these first two years, MADFORWATER partners developed at laboratory scale technologies for wastewater treatment and irrigation with treated wastewater, and set the basis for the development of integrated water management strategies. During the last two years of activity selected technologies will be scaled up in 4 demonstrator plants of integrated wastewater treatment and irrigation with treated wastewater, and the integrated water management strategies will be finalized.

This newsletter is mainly focused on the presentation of the results relative to the lab-scale development of technologies. You will also find a short analysis of the use of economic instruments in water management in Egypt, Morocco and Tunisia, and a presentation of the MADFORWATER consortium. The next newsletter will be released in May 2019.

Enjoy the reading! If you would like to receive further information or to set up collaborations, feel free to contact us:

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Contents

Wastewater treatment technologies developed by the MADFORWATER project

Innovative approaches for the treatment of municipal wastewater

Main pollutants to be removed for an agricultural reuse

Organic compounds, nitrogen, phosphorous, TSS and pathogens

Technologies mainly used in Egypt, Morocco and Tunisia for the treatment of this wastewater

Most of the municipal wastewater treatment plants located in Tunisia and Egypt use conventional aerobic activated sludge process (at low and medium loads) as secondary treatment. A lower number of plants possess tertiary treatment for N and P removal with aerated lagoons. UV disinfection is used for the tertiary treatment only at pilot scale plants. The main disadvantage of the activated sludge process is the consumption of electrical energy for aeration, whereas the main disadvantage of aerated lagoons is the low efficiency in removing ammonia nitrogen or phosphorous. COD and BOD5 contents of the treated municipal wastewater by the above mentioned processes generally exceeds the limits imposed by the local (e.g., NT 106.03) and ISO standards for the reuse of treated wastewater for irrigation. Moreover, the microbiological content of the treated wastewater presents a health concern if it is used for irrigation in agriculture.

Short presentation of the technologies developed by MADFORWATER for this wastewater

The challenge is to develop a treatment train able to attain high treatment efficiency and reliability, with reduced capital, operation and maintenance costs. MADFORWATER is developing one technique, which consists in nitrifying trickling filters with innovative high specific-surface carriers, for the secondary treatment of municipal wastewater wastewater. As tertiary treatment, two techniques are tested: a) constructed wetlands to remove N, P, heavy metals and emerging pollutants and b) Immobilized enzyme bioreactors for the degradation of emerging pollutants. These technologies are briefly presented in the following tables.

NITRIFYING TRICKLING FILTERS WITH INNOVATIVE HIGH SPECIFIC-SURFACE CARRIERS

Specific pollutants targeted by this technology

Residual BOD, nitrogen, phosphorous, and pathogens

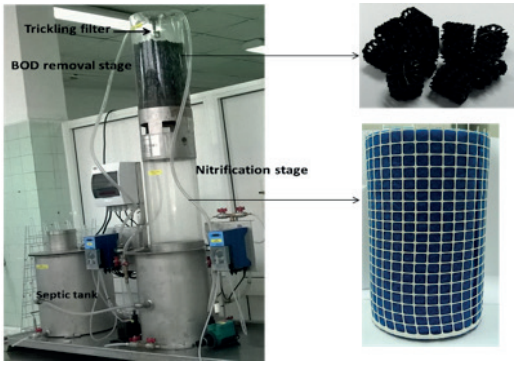
Technology description

A trickling filter consists of permeable medium made of a bed plastic (of rock or slag) over which wastewater is distributed to trickle through. It also includes a distribution system. A rotary hydraulic distribution is usually standard for this process.

This technology aims to:

- reduce retention times thanks to the attainment of a high biofilm thickness,
- improve the nitrification / denitrification performances.

The lab scale trickling filter is configured as a two-stage system. In the first stage, the removal of BOD, is accomplished, followed by the second stage where nitrification is achieved.



Pilot scale trickling filter for municipal wastewater treatment

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

Trickling filters may be suitable for the target countries thanks to the low maintenance, cheap installation and high stability against fluctuation of hydraulic and organic loads. The operation of a trickling filter has as well the advantage of not requiring an external air supply, which reduces energy consumption, since air is naturally convected through it, due to the temperature difference between its interior and exterior. Moreover, the proposed system combines the secondary and the tertiary treatment allowing the removal of both BOD and ammonia nitrogen, which make it suitable to obtain irrigation quality water.

Results obtained in MADFORWATER

A removal efficiency of up to 85% of COD was achieved with a hydraulic retention time of 20 days. Results showed a removal efficiency of about 88% with a residual BOD of about 25 mg/l. The treated effluent meet the Tunisian (NT 106.03) and ISO standards for wastewater reuse in agriculture in terms of COD (COD<90 mg/L) and BOD (BOD<30 mg/L).

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

This technology is considered as secondary treatment and a part of tertiary treatment. Further treatments for pathogen removal should be integrated.

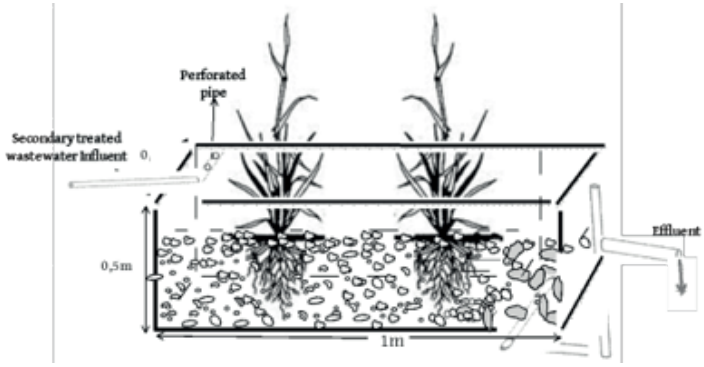
CONSTRUCTED WETLANDS

Specific pollutants targeted by this technology

Heavy metals, HMs (Ni, Cd, Zn) and emerging organic contaminants (EOCs) (bisphenol A, ciprofloxacin, sulfamethoxazole).

Technology description

CWs for wastewater treatment involve the use of engineered systems that are designed and constructed to utilize natural processes. These systems are designed to mimic natural wetland systems, utilizing wetland vegetation, soil, and associated microorganisms to remove contaminants from wastewater effluents. They can achieve multiple goals of contaminant removal such as total suspended solids, biochemical oxygen demand, organic compounds, and inorganic constituents to meet regulatory targets. Horizontal subsurface flow CW mesocosms made from stainless steel, filled with gravel and planted with the Mediterranean haloplyte *Juncus acutus* L. is fed with municipal wastewater polluted with heavy metals and emerging organic contaminants.



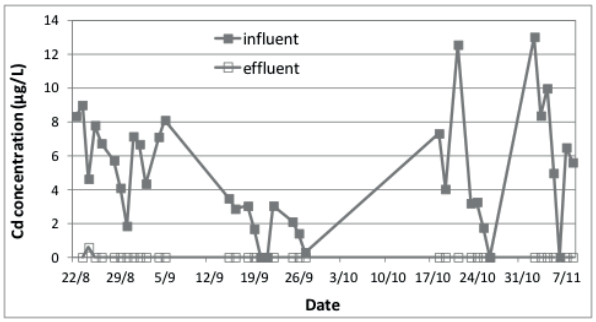
Representation of the horizontal subsurface flow system, for the treatment of municipal wastewater contaminated with EOCs/HMs.

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

Constructed wetlands are low cost, low-energy, easily operated and maintained compared to conventional treatment systems, able to achieve contaminants removals to meet regulatory targets and have a strong potential for application in developing countries, particularly by small rural communities. Moreover, as selection of the appropriate plant species is an important efficiency parameter and medittereannean halophytes are proven to be ideal candidates.

Results obtained in MADFORWATER

With influent municipal wastewater heavy metals concentrations up to twice the limits for WW reuse for irrigation, CWs means removal capacities up to 99% for Cd, 51% for Ni and 45% Zn are noted. With influent concentrations of emerging organic contaminants 100µg/L of bisphenol A (BPA), 1mg/L of ciprofloxacin (CIP) and 5 mg/L of sulfamethoxazole (SXS), CWs means removal efficiency up to 76% for BPA, 94% for CIP and 27% for SXS are recorded. These results have been obtained without the effect of growth promoting bacteria on the overall efficiency of the process.



Cd concentration in the constructed wetland influent and effluent

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

None

IMMOBILIZED ENZYME BIOREACTORS

Specific pollutants targeted by this technology

Pharmaceuticals, organic micropollutants.

Technology description

This technology utilizes laccases immobilized onto resin particles with a low pressure drop in a packed bed reactor fed with a continuous flow of wastewater. Laccases have been selected since they can catalyze the oxidation of a wide range of phenolic and nonphenolic lignin-related compounds, including many pharmaceuticals and micropollutants commonly occurring in municipal WW and typically not degraded in conventional municipal WWTP, they can be relatively simply isolated and purified from white rot fungi. Besides allowing continuous operation, immobilization on solid supports has been demonstrated to enhance enzyme stability.

Packed bed column with immobilized enzymes

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

The packed bed reactor is easy to operate, does not require sophisticated instrumentation, regulation or high pressure pumps and it could be more suitable compared to other reactor configurations, such as membrane reactors, for wastewater treatment in African countries.

Results obtained in MADFORWATER

Laccases from *P. sanguineus* (L1) and *T. versicolor* (L2) were immobilized onto resin particles or fumed silica nanoparticles (fsNP) and tested in a batch reactor on spiked municipal wastewater (500ng/L of each compound). The most efficient laccase (from *P. sanguineus*) removed 7-83% of the pharmaceuticals after 5 days. Treatment of the real municipal wastewater was performed with the laccase from *P. sanguineus* in a packed bed reactor with a continuous flow rate. Adsorption of the micropollutants onto the enzyme carriers was observed in preliminary tests, hampering quantification of the pollutants degradation; further experiments are in progress.

Compound (ng/L)	Tunisia	Dragra	Tiznit
4-Acetamidoantipyrin	n.d.	163	112
Amisulpride	78	n.d.	101
Atenolol	384	117	219
Atenolol Acid	151	124	90
Carbamazepine	237	245	443
Carbendazim	50	99	162
Celiprolol	180	n.d.	19
Climbazole	279	719	583
Fluconazole	164	512	407
Irbesartan	461	101	46
Niflumic Acid	383	389	218
Sulpiride	161	70	178

Concentrations of pharmaceuticals in real municipal wastewater samples from Tunisia and Morocco

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

This technology is considered as tertiary treatment. Primary treatment and secondary biological treatment should be integrated. Costs of enzymes and resin used for immobilization are relatively high.

An innovative approach for the treatment and valorization of olive mill wastewater

Main pollutants to be removed for an agricultural reuse

Organic compounds (COD 20-100 g/L); polyphenols (1-10 g/L)

Technologies mainly used in Egypt, Morocco and Tunisia for the treatment of this wastewater

According to Tunisian legislation, the main practice to manage olive mill wastewater (OMWW) is to discharge it into evaporation ponds. This treatment process aims to reduce the impact of OMWW on the environment, with the unfortunate side effect of severe odor emission. This is caused by the flotation of residual oily substances in the OMWW, inhibiting evaporation and creating anaerobic conditions. Odors are the main disadvantage of evaporation ponds, especially for those operating near domestic areas.

Short presentation of the technologies developed by MADFORWATER for this wastewater

MADFORWATER is developing two alternative treatment trains for OMWW: the first one is articulated in suspended solids removal by microfiltration, polyphenol recovery from the filtrate by adsorption and final BOD removal by biomethanation; the second one consists in an aerobic biological treatment in a sequenced batch reactor with lime addition. These technologies are briefly presented in the following tables.

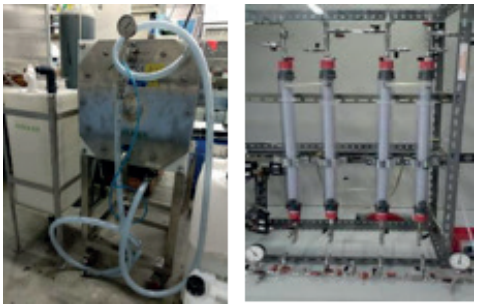
MICROFILTRATION AND POLYPHENOL RECOVERY BY ADSORPTION

Specific pollutants targeted by this technology

Suspended solids and polyphenols

Technology description

An initial microfiltration step, aimed at the removal of suspended solids, is followed by an adsorption / desorption step aimed at the recovery of polyphenols. This leads to the production of i) a polyphenol-rich mixture that, thanks to its high antioxidant capacity, can find application in several industrial processes or products formulation and ii) a dephenolized water that can be treated biologically more efficiently. Two columns operate in parallel: while the first one adsorbs polyphenol from olive mill wastewater, the second desorbs the antioxidants collected during the previous cycle. The desorption solvent (typically ethanol) is entirely recycled within the process by evaporation and re-condensation.



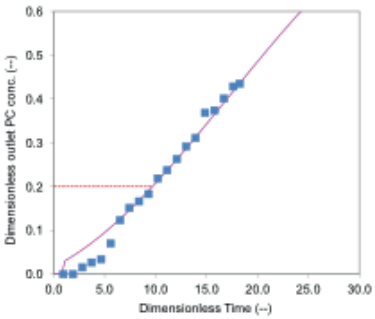
Pilot plants for the microfiltration and adsorption of olive mill wastewater

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

This technology is suitable for the North African context thanks to its capacity to produce an antioxidant mixture that can potentially have a relevant market value. At the same time, the removal of polyphenols from olive mill wastewater is important in order to avoid any potential crop damage associated to the antioxidant and antimicrobial activity of these compounds.

Results obtained in MADFORWATER relatively to this technology

The removal of suspended solids by filtration was very high (98%) and characterized by a limited, acceptable loss in polyphenols (9%) with the solids. Different types of resins were tested for the polyphenol recovery step from the water phase. A neutral adsorption resin (XAD 16) was selected as the most effective one. It leads to the recovery of a polyphenol mixture characterized by a very high antioxidant capacity. Polyphenol removal is equal to about 90%, leading to a residual polyphenol concentration in the treated effluent equal to about 0.1 g/L.



Polyphenol outlet concentration versus time in the outlet of an adsorption test. Experimental data and best-fitting simulation

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

- In order to produce an irrigation-quality water, the proposed technology must be integrated by a treatment step aimed at the biodegradation of organic compounds (e.g., anaerobic digestion).
- The operation of the proposed technology requires personnel with adequate technical skills, capable to manage adsorption, evaporation and condensation processes.
- Some safety issues are related to the need to stock ethanol. Local legislation on safety in workplaces must be carefully applied.

ANAEROBIC DIGESTION

Specific pollutants targeted by this technology

Organic matter

Technology description

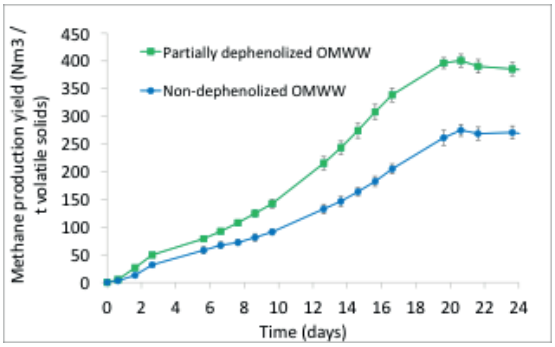
Biodegradable organic compounds (BOD) are converted into methane and carbon dioxide thanks to the combined action of acidogenic and methanogenic microorganisms. The process is operated under anaerobic conditions at 35-40 °C in a stirred reactor. Dephenolized olive mill wastewater can be co-digested in combination with other agricultural wastes. The produced biogas is typically burned, leading to a combined production of heat and electrical energy.

Anaerobic digestion pilot plant

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

Anaerobic digestion is characterized by a medium-low level of technical complexity and by a null energy consumption. On the other hand, it leads to the production of electrical energy that can be sold to the local energy grid. The production of irrigation-quality water requires a high retention time for the complete removal of BOD, and a further treatment step for solid / liquid separation (for example, a filter-press). The solid digestate produced can be used as a fertilizer.

Results obtained in MADFORWATER



Methane production yield obtained with dephenolized and non-dephenolized OMWW

The results indicate that olive mill wastewater is a good candidate for the anaerobic digestion process, with a relatively high yield of methane production (260-400 $NL_{CH4}/kg_{Volatile\ Solids}$) and an acceptable methane production rate (110-200 $L_{CH4}/m3_{digestate}/d$). Previous olive mill wastewater dephenolization leads to a 30-40% incerase of the process performances. The tests aimed at evaluating the capacity of the process to attain the low BOD concentrations required by the ISO standards for water reuse in agriculture (< 100 mg/L) are still in progress.

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

Anaerobic digestion of olive mille wastewater is considered suitable for the specific context of Egypt, Morocco and Tunisia.

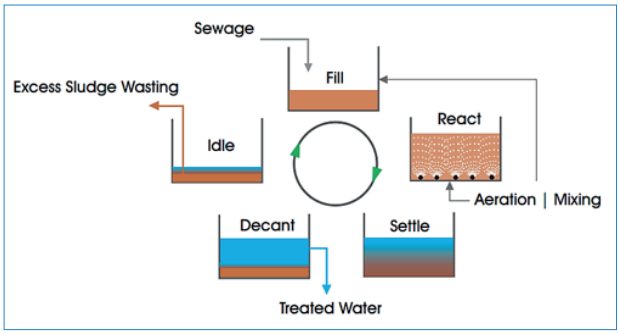
AEROBIC BIOLOGICAL TREATMENT IN A SEQUENCED BATCH REACTOR

Specific pollutants targeted by this technology

Organic compounds, Phenolics

Technology description

Sequenced Batch Reactors (SBR) are a special form of activated sludge treatment in which the whole treatment process takes place in the reactor tank and clarifiers are not required. This process treats the wastewater in batch mode and each batch is sequenced through a series of 5 treatment stages: 1. Fill; 2. React; 3. Settle; 4. Decant and 5. Idle.



SBR operating principle

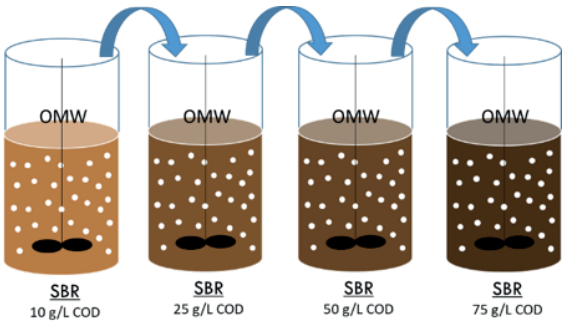
First, the tank is filled by the OMWW. During the second stage, mixing is provided by mechanical means and aeration of the mixed liquor is performed via diffusers fixed to the floor of the tank. No aeration and mixing are provided in the third stage to settle the suspended solids. During the fourth stage the OMWW treated supernatant is recovered. In the fifth stage the excess sludge is removed. The treated wastewater is then subject to lime addition under pulverulent form (CaO) until pH 12.

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

Sequencing batch reactor (SBR) could be applied for nutrients removal, high biochemical oxygen demand containing industrial wastewater, wastewater containing toxic materials such as cyanide, copper, chromium, lead and nickel, food industries effluents, landfill leachates and tannery wastewater. Of the process advantages are single-tank configuration, small foot print, easily expandable, simple operation and low capital costs. Moreover, it allowed the establishment of a stable microbial population, capable of degrading potentially toxic compounds. The addition of pulverulent lime permits further removal of COD and phenolics by both coagulation and adsorption phenomena.

Results obtained in MADFORWATER

The SBR reactor was seeded with a sample of activated sludge from a municipal wastewater treatment plant, which was stepwise acclimatized towards the high COD content present in the OMWW by operating the reactor for several sequenced batches with a hydraulic retention time of 30 days each and increasing COD concentrations in the influent OMWW up to 75 g L-1. Similar COD reduction efficiencies (about 60%) have been achieved after each sequenced batch with a stable removal rate of 1.5 gCOD L-1 D-1, indicating the presence of a stable microbial consortium. The combination of biological treatment to pulverulent lime addition allowed the removal of up to 80% and 90% of COD and phenolics respectively. However, the COD of the treated OMWW still exceeds the standards for irrigation water indicated in ISO and Tunisian standards (NT 106.03).



Stepwise acclimatization of the aerobic consortium to high OMWW concentrations in a SBR

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

This technology is suitable for the specific context of Egypt, Morocco and Tunisia. No specific obstacles are reported in relation to the production of irrigation-quality treated wastewater. However, additional dilution or treatment is required in order to further reduce the remaining COD concentration.

Innovative treatment trains for textile wastewater

Main pollutants to be removed for an agricultural reuse

Azo dyes, sulfonated azo dyes

Technologies mainly used in Egypt, Morocco and Tunisia for the treatment of this wastewater

The current situation of textile wastewater (TWW) treatment in these three countries is quite diverse. Some textile companies from have already integrated internal wastewater treatment processes into their process sequences, aiming to reach up to 60% reintegration of the sewage into the processes. The remaining treated wastewater is discharged into the municipal sewage network. Coagulation is a widely applied process as a pre-treatment prior to principal treatment by activated sludge, oxidation or membranes. Coagulation aims to remove colloidal particulates and organic substances. The efficiency of the current processes is generally instable in relation to the important daily and seasonal variation of effluents volume and of organic and mineral load. An adequate process able to tolerate occasional peaks of effluent volume and organic load must be used. In some cases, textile effluents are discharged directly into the municipal sweage network without any pre-treatment.

Short presentation of the technologies developed by MADFORWATER for this wastewater

MADFORWATER is developing a secondary treatment process in moving bed biological reactor (MBBR) to be applied downstream a coagulation/flocculation step, in order to degrade COD and azodyes, and two alternative tertiary treatment processes aimed at removing the residual dyes, namely i) dyes enzymatic degradation in packed bed reactors with immobilized laccases and, ii) dyes adsorption/desorption with innovative magnetic resins. These technologies are briefly presented in the following tables.

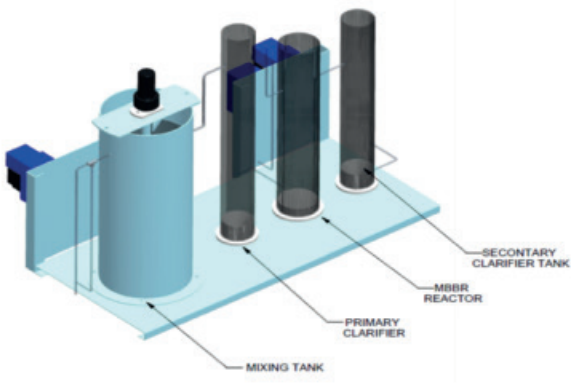
MOVING BED BIOLOGICAL REACTOR

Specific pollutants targeted by this technology

Toxic azodyes

Technology description

The wastewater contaminated with toxic dyes is pumped into the first mixing tank with a peristaltic pump where coagulants - flocculants are added and then it overflows to the primary clarifier for precipitation of suspended particles. The supernatant wastewater from this tank flows to the tank with carriers (MBBR), where biological degradation occurs. An aerator provides oxygen to the water and fluidize biofilm carriers. The sludge is allowed to settle in the secondary clarifier tank which follows, while the effluent from this tank is recirculated through a peristaltic pump to the biodegradation tank (MBBR). The system was operated as a batch reactor, since only the MBBR reactor and the secondary clarifier tank were operated by recirculation.



Laboratory scale plant for the treatment of textile WW in a moving bed biological reactor (MBBR)

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

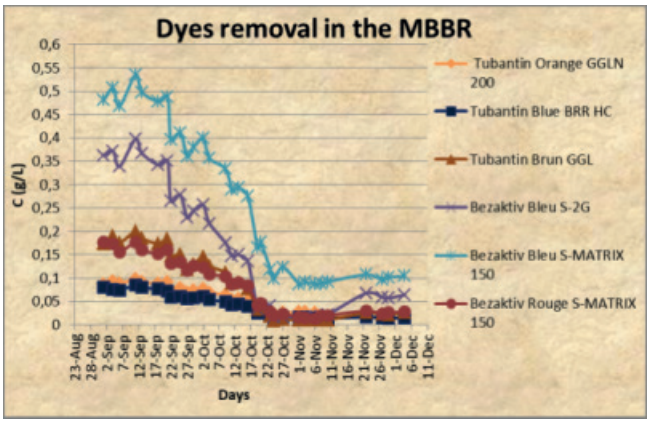
This technology has proven effective in the biodegradation of dyes whose presence in textile wastewaters has been identified as a critical issue for their reuse in irrigation.

Specific features that make this technology suitable for a MAC context and for the attainment of the international standards for agricultural WW reuse

This technology has proven effective in the biodegradation of dyes whose presence in textile wastewaters has been identified as a critical issue for their reuse in irrigation.

Results obtained in MADFORWATER

MBBR was fed with synthetic wastewater supplemented with 0.08 to 0.48 g L-1 dye concentrations. These concentrations are typically obtained after primary treatment with coagulants. An efficient consortium isolated from marine environment was inoculated to the system, developing the biomass on freely moving carriers. The decolorization efficiency of the system was above 80% for all tested dyes after 95 days operational period. Ammonium nitrogen, total nitrogen and total phosphorous were measured 1.2, 35 and 2.7 mg/l respectively. According to the maximum levels of nutrients in TWW used for irrigation (ISO 16075-1-2015) which are 30 for ammonium nitrogen, 35 for total nitrogen and 7mg/l for total phosphorous the treated TWW can be used for irrigation.



Dyes removal from textile WW in the moving bed biological reactor (MBBR)

Specific obstacles relative to the application of this technology in a MAC context and to the production of irrigation-quality treated WW

Overall, there should be no problem in the application of the MBBR technology; however, care should be taken of the sludge removal from the primary step. If the quantities are small (when expensive coagulants are used) simple drying and disposal should be OK. In the case where lime is used, the amount of watery sludge being produced is very high (almost 30 to 50% of the initial wastewater volume) and a specific treatment technology for this must be considered.

TECHNOLOGY: IMMOBILIZED ENZYME BIOREACTORS

Specific pollutants targeted by this technology

Azo dyes, sulfonated azo dyes

Technology description

Laccases and peroxidases are known enzymes with ability to decolorize various types of dyes. This technology is utilizing immobilized enzymes in packed bed reactor to treat textile wastewater. Immobilization of the enzymes usually improves enzyme stability. Resin particles (100-300μm size) were used as enzyme carriers and the packed bed reactor is operated at continuous flow rate.

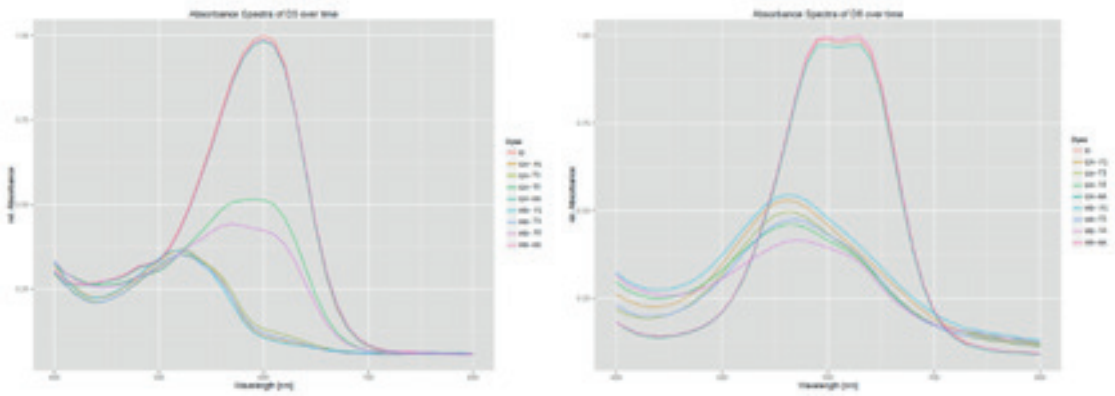
Lab-scale bioreactor for dye removal with immobilized enzymes

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

The packed bed reactor is easy to operate, does not require sophisticated instrumentation, regulation or high pressure pumps and it could be more suitable compared to other reactor types using immobilized enzymes, such as membrane reactors, for wastewater treatment in African countries.

Results obtained in MADFORWATER

Six sulfonated azo dyes have been selected as the main contaminants of the real textile wastewater. Laccases from the fungi P. sanguineus and T. versicolor were able to decolorize two out of six dyes. Dye-decolorizing peroxidase did not remove any of the dyes and horseradish peroxidase degraded only one dye. Redox mediators enable laccase to oxidize more compounds. The oxidation step is performed by the oxidised form of the mediator, generated on its interaction with laccase. Three different redox mediators have been tested and 1mM 1-hydroxybenzotriazole showed the highest extent of decolorization. Partial decolorization was observed in the real textile wastewater that was spiked by six dyes and treated by laccase from T. versicolor. In experiments performed with immobilized laccases, dyes adsorption of the enzyme carrier mainly occurred, with negligible dyes degradation. Work is in progress to improve the degradation performance of the immobilized enzyme by changing reaction conditions.



Decolourization of dyes Bezaktiv Bleu S-Matrix 150 and Bezaktiv Bleu S-2G by laccases, as indicated by the reduction of absorbance at 600 nm.

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

This technology is highly dependent on quality of the textile wastewater. Enzymes are not able to decolorize a big range of structurally different dyes and if the composition of the wastewater significantly fluctuate this technology may become inefficient. Negatively charged dyes are adsorbed by the enzyme carriers. Costs of enzymes and resin used for immobilization are relatively high.

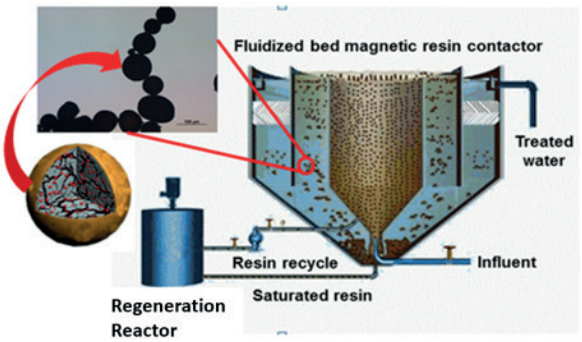
ADSORPTION ON INNOVATIVE RESINS

Specific pollutants targeted by this technology

Dyes and dissolved organic matter

Technology description

The magnetic anion exchange resin (MAER) developed by Nanjing University, China is designed specifically to remove organic matter and negative-charged dyes from water and wastewater. The MAER has a polyacrylic matrix, a macroporous structure and strong-base functional groups. The resin beads have a diameter of 100-200 um, which has high surface area and mass transfer rate than the convention resins. The MAER is used in suspended manner in a completed mixed flow reactor. The magnetic core aids agglomeration and settling of the resin. The MAER can be regenerated by 10% NaCl solution and the reactor utilize a side-stream, continuous regeneration process allowing for a consistent treated water quality. About 200~300 m3 wastewater generates 1 m3 brine wastewater.



The magnetic anion exchange resin and the fluidized-bed reactor

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

The MAER has fast and good treatment capacity for removal of most negative-charged organic matter and dyes. However, the usage of NaCl and the treatment of the brine wastewater from resin regeneration process limits it large application. The textile factory in these countries usually generates ~200 m3 wastewater per day, which means ~ 1 m3 brine wastewater is produced every day. The price of NaCl is cheap and the brine wastewater can be easily evaporated according to local drought climate.

Specific features that make this technology suitable for a MAC context and for the attainment of the international standards for agricultural WW reuse

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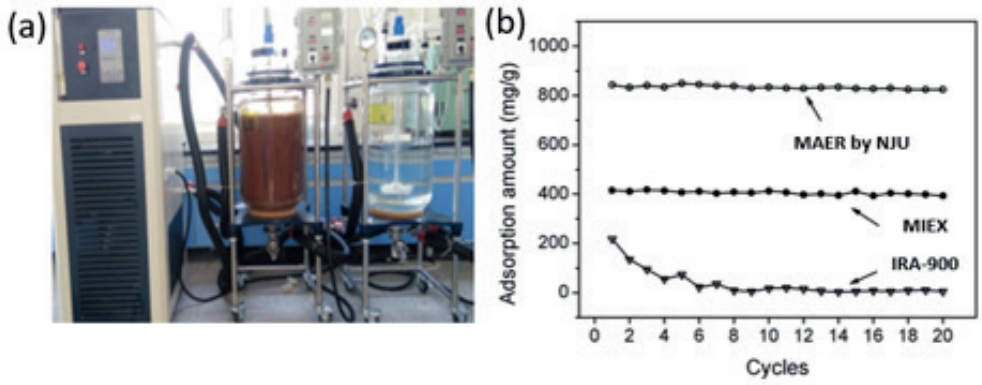
Results obtained in MADFORWATER

A novel permanent-magnetic anion exchange resin MAER was developed by use of diallyl itaconate (DAI) as the crosslinker, which significantly improved the hydrophilicity, strength and adsorption capacity. The dye-saturated MAERs can be efficiently regenerated by a mixture of NaCl/NaOH solution (10%/1%). During 20 cycles, the MAER could be reused without a noticeable decline in adsorption capacity for the dye Orange-G, indicating a superior anti-fouling performance for removal of organic matter. Taken together, the high capacity, fast kinetics, excellent reusability and convenient separability of MAER made it a good candidate for organic matter removal.



The synthesis for the permanent-magnetic anion exchange resin (MAER) and its adsorption capacity to the dye Orange-G in comparison with the commercial MIEX and IRA-900 anion exchange resin

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

The anion exchange resins cannot remove those fibers, organic matter or dyes which are not negatively-charged in textile wastewater. This technology must comply with the other wastewater treatment technologies.

A sustainable approach for the treatment of fruit and vegetable packaging wastewater

Main pollutants to be removed for an agricultural reuse

Organics (COD), suspended solids, fungicides

Technologies mainly used in Egypt, Morocco and Tunisia for the treatment of this wastewater

Depending on local conditions, different treatment options are used, such as septic tanks, aerobic lagoons or activated sludge process is currently used for wastewaters from fruit and vegetable packaging. These treatment technologies are capable of removing part of the critical contaminants (persistent organics, suspended solids and fungicides), but the resulting effluent quality is low with respect to the reuse standards.

Short presentation of the technologies developed by MADFORWATER for this wastewater

To achieve high quality effluent which can meet reuse standards, a treatment train combining different technologies was designed: Moving bed biofilm reactor (MBBR) to remove organic contaminants, Integrated flotation and flocculation to efficiently remove suspended solids and UV-Oxidation/Immobilised enzymes to remove residual fungicides. As an alternative to the last technology, sorption on activated carbon can be applied for the fungicide removal. These technologies are briefly presented in the following tables.

AEROBIC MOVING BED BIOREACTOR (MBBR)

Specific pollutants targeted by this technology

Pharmaceuticals, organic micropollutants.

Technology description

The technology is based on the use of small plastic carrier elements with density similar to water colonized by microorganisms and forming a biofilm. The carriers are mixed with wastewater in an aerated tank and the microorganisms remove degradable organic matter from the wastewater. Aeration of the bioreactor serves for mixing and supply of oxygen to the microorganisms. The needed contact time for the specific wastewater is approx. 1 day. The treated water is removed from the bioreactor, whereas the carriers are retained by a sieve. The biological processes generate certain amount of excess biomass, which is removed in the subsequent flocculation and dissolved air flotation (DAF) step, together with the suspended solids originating from the wastewater.

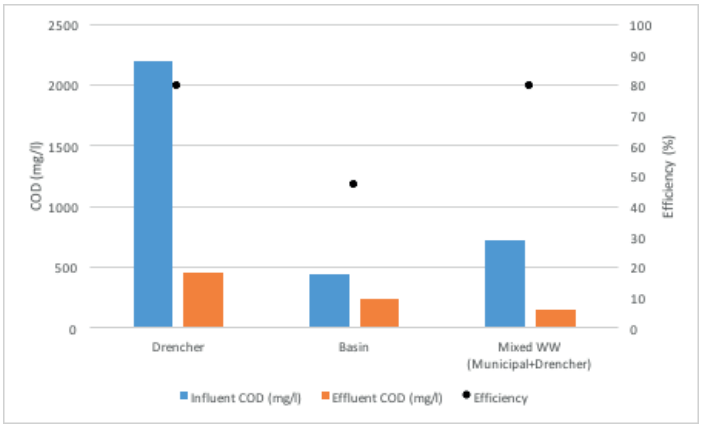
MBBR carriers with developped biofilm

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

The presence of toxic and poorly degradable compounds in the specific wastewater can negatively affect the microorganisms during the biological treatment. The biomass attached to the carriers is less sensitive to these compounds and can be reliably retained in the reactor, preventing the wash-out of slow growing organisms. The MBBRs also allow high biomass density and thus the use of compact reactors. The technology is simple to implement and operate.

Results obtained in MADFORWATER

Various wastewater streams originating from the fruit and vegetable processing, as well as their mixtures, were treated by the MBBR technology. The MBBR technology itself could remove 65 to 80 % of the organic contamination (COD). Some fungicides were efficiently removed as well, but others remained in the wastewater in the treated water. The wastewater also contained suspended solids. These contaminants are addressed by the second step of the treatment technology: integrated flocculation and flotation, which is an integral part of the proposed treatment train.*sanguineus* in a packed bed reactor with a continuous flow rate. Adsorption of the micropollutants onto the enzyme carriers was observed in preliminary tests, hampering quantification of the pollutants degradation; further experiments are in progress.



COD removal from different wastewater samples by MBBR technology

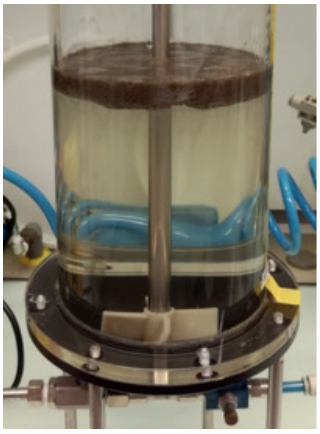
Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

The production of the wastewater from fruit and vegetable packaging/processing is seasonal. However, the MBBR – like other biological wastewater treatment methods – relies on continuous supply of substrate. Alternative wastewater (e.g. a municipal stream) is necessary for the downtime periods.

INTEGRATED FLOTATION & FLOCCULATION

Specific pollutants targeted by this technology

Suspended solids, colloids.



Separation of suspended solid in a lab scale flotation unit

Technology description

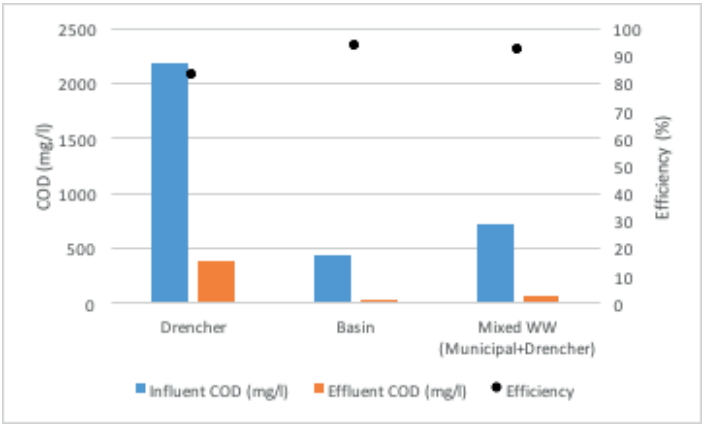
The principle of dissolved air flotation (DAF) is the removal of suspended particles from wastewater by using micro-bubbles which are generated once pressurized and air-saturated water is released to ambient pressure. The bubbles attach to the particles and carry them to the surface, where they form a sludge blanket (up to 3 - 6% dry solids). The particles in the wastewater need to be coagulated and flocculated before the introduction of air-saturated water to facilitate the agglomeration between the particles and micro-bubbles. In the proposed scheme DAF is coupled to MBBR treatment to remove particles and excess biomass. Optionally powdered activated carbon can be dosed to the influent to the DAF for the sorption of residual fungicides.

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

Compared to sedimentation the energy consumption of DAF is higher, on the other hand it can provide very high efficiency of solids removal at very short hydraulic retention time (few minutes). This enables construction of a compact unit with high volumetric throughput. Highly efficient removal of contaminated solids from the fruit packaging wastewater provides highly purified water suitable for reuse and it is also crucial for the subsequent post-treatment by UV-Oxidation/Immobilised enzymes.

Results obtained in MADFORWATER

The combined DAF process could efficiently remove suspended solids from all tested wastewater samples originating in the fruit and vegetable packaging plant (both before and biological treatment) to <5 mg/l. Together with the MBBR unit the COD removal efficiency was 80-90%, depending on wastewater composition (Figure 4). The best water quality was COD < 30 mg/l and BOD < 5 mg/l. The combined process could also remove fungicides to < 0.1 mg/l, except for thiabendazol. Dosing of powdered activated carbon to the influent of the flotation could provide additional removal of the fungicide (approx. 90%).



COD removal from different wastewater samples by a combination of MBBR + DAF

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

No specific obstacles are reported.

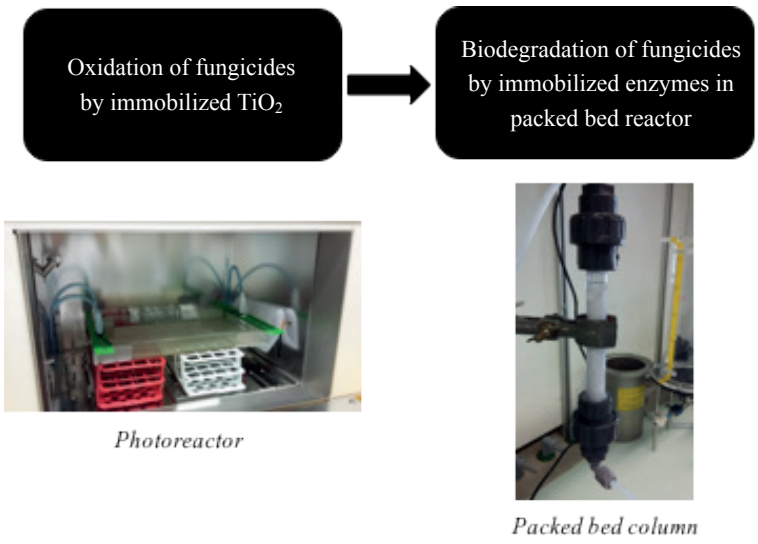
UV-OXIDATION WITH TIO2–COATED BEDS COMBINED TO IMMOBILIZED ENZYME BIOREACTORS

Specific pollutants targeted by this technology

Thiabendazole.

Technology description

The post treatment is performed in a photoreactor with immobilized titanium dioxide. The reactor is operating continuously at sunlight. The main photo-transformation products are hydroxy derivatives of fungicides which represent more amenable substrates for biocatalytic degradation. The following treatment technology is utilizing immobilized laccases. Resin particles with a low pressure drop were selected as enzyme carriers thus a continuous packed bed reactor can be constructed and operated.



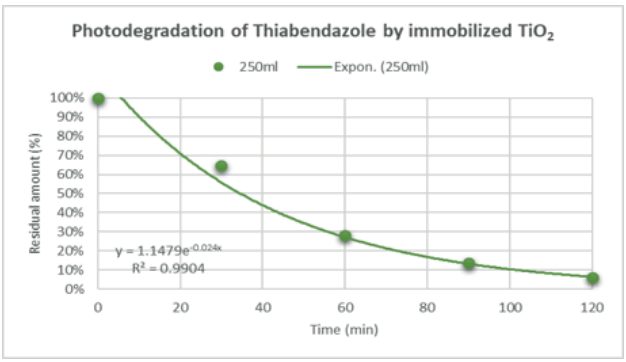
Packed bed reactor for the enzymatic treatment of fruit packaging wastewater

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

The photoreactor does not require UV lamps or energy for oxidation. It can be operated at sunlight. The packed bed reactor is easy to operate, does not require sophisticated instrumentation, regulation or high pressure pumps and it could thus be more suitable than other bioreactor configurations, such as membrane bioreactors, for wastewater treatment in African countries.

Results obtained in MADFORWATER

Thiabendazole in synthetic wastewater could be degraded by immobilized titanium dioxide up to 94% in 120 min. Analysis of titanium dioxide particles in treated effluent showed a very low release (<1%) which confirmed a good mechanical stability of the immobilized photocatalyst. However, efficiency of the photo-reactor was significantly influenced by wastewater matrix and decreased by biofouling, since photodegradation of thiabendazole in real wastewater was not observed. Washing steps of the photoreactor should be incorporated in the treatment process. Degradation of thiabendazole by immobilized laccases was not observed.



Photodegradation of thiabendazole by immobilized laccase

Specific obstacles relative to the application of this technology in Egypt, Tunisia and/or Morocco and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

The photoreactor can operate only during the day because a sunlight is required. Additional UV lamps has to be installed if operated at night. Costs of enzymes and resin used for immobilization are relatively high.

A sustainable approach for the treatment and valorization of Drainage Canal Water

Main pollutants to be removed for an agricultural reuse

Organic compounds (COD 200-600 mg/L); ammonia (2-10 mg/L) and nitrate (2-10 mg/L).

Technologies mainly used in Egypt, Morocco and Tunisia for the treatment of this wastewater

No treatment is actually performed on drainage canal water before it is used for irrigation.

Short presentation of the technologies developed by MADFORWATER for this wastewater

MADFORWATER is developing the use of canalized facultative lagoons in order to remove BOD and N (nitrification/denitrification) from drainage water of the Nile delta region. The aim is to propose the conversion of the existing drainage canals receiving drainage water and local wastewaters into canalized facultative lagoons through proper design.

FACULTATIVE CANALISED LAGOON

Specific pollutants targeted by this technology

Organic compounds, ammonia and nitrate.

Technology description

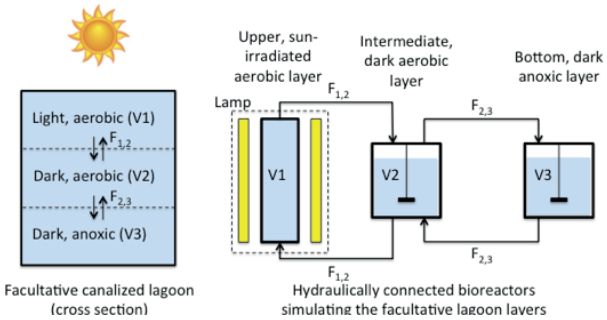
The technology consists in canals, where contaminated water flows by gravity, properly designed in terms of geometry (e.g., depth) and fluid dynamics (e.g., through baffles) in order to attain the establishment of i) an upper sun-irradiated aerobic layer, where microalgal growth contributes to water oxygenation, ii) a dark aerobic layer, where only growth of aerobic, COD-removing heterotrophic bacteria and of chemolitotrophic ammonium-oxidizing bacteria takes place, iii) a lower anoxic/anaerobic layer, where facultative bacteria reduce nitrate further contributing to COD removal, and iv) the suitable oxygen and mass transfer rates between layers.

Specific features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the attainment of the ISO 16075 standard for agricultural WW reuse

This technology is suitable for the North African context thanks to the warm climate that allows an effective removal of pathogens and coliforms. Because of the simplicity in construction and low power and maintenance costs, especially with systems designed to operate with gravity flow, facultative lagoons are also desirable in developing countries. Drainage canals are already existing in the Nile delta area: a conversion of the existing canals into facultative canalized lagoons would not impact significantly on the surface of land covered (a typical disadvantage of conventional facultative lagoon ponds).

Results obtained in MADFORWATER relatively to this technology

A laboratory reactors system consisting in three hydraulically connected bioreactors (V1, V2, V3, see figure) was set up to simulate the layers of facultative canalized lagoons, i.e., the COD removal, nitrification and denitrification processes taking place, and the mass transfer phenomena among them. The dark portion of the system (V1 reactor disconnected and replaced by air purging in V2 reactor) was tested preliminarily on a synthetic WW inoculated with a bacterial community previously enriched from a drainage canal of the Nile delta area. Removal of initial COD (450 mg L^{-1}) up to 90 mgL^{-1} (overall average removal rate of 65 ± 4 mg L^{-1} h^{-1}), as well as a NH_4-N removal rate of 2.4 ± 0.3 mg L^{-1} h^{-1} and NO_3-N removal rate of 25 ± 2 mg L^{-1} h^{-1} were observed when the 2 reactors (V2 = 2L, V3 = 1L) were hydraulically connected with a flow rate of 2.08 mL min-1. Connection of the aerobic photo reactor (V1) and optimization of the layers volume ratio and flow rate, will provide the information on the canal depth and turbulence required to convert it in a facultative lagoon system able to attain the water quality standards for irrigation.



Schematic representation of the facultative canalized lagoon layers and of the laboratory plant set up for the simulation of facultative canalized lagoons.

Specific obstacles relative to the application of this technology in Egypt and to the production of irrigation-quality treated wastewater according to the ISO 16075 standard

- Optimization may require the modification of the geometry (depth) and fluid dynamics (insertion of baffles) of specific canal portions
- Limited control on the operating parameters (e.g., turbulence through modification of baffles distance and depth); seasonal changes of weather conditions (temperature, light intensity, daylight duration) might partially affect the process performances.

Irrigation technologies developed by the MADFORWATER project

AN EFFICIENT LOW-PRESSURE ANTI-DRIFT MICRO SPRINKLER ADAPTED TO TREATED WASTEWATER

Type of crops "targeted" by this technology

This innovative mini-sprinkler is designed in particular for orchard trees with under canopy irrigation.

Benchmark technology used in Egypt, Morocco and Tunisia for the irrigation of these crops

In the targeted countries the orchards are typically irrigated by drippers, when the water is of good quality, or micro-sprinklers when clogging problems are more frequent due to the suspended solids carried by the irrigation water.

Technology description

This technology can be used to irrigate orchard trees under canopy in a configuration that prevents water contact with the consumable parts of the plant. The objective is to develop a low-cost mini-sprinkler, that minimizes pathogen risk dissemination due to aerosols issued from the smaller droplets and that resists to the potential clogging related to the use of treated wastewater. This micro-sprinkler, designed to manage the size of droplets produced to minimize the generation of small droplets, is intended to work at low operating pressure (< 2 bar). The droplet diameter varies between 0.5 mm and 2.5mm: higher than 0.5 mm to avoid droplet drift because of wind and lower than 2.5 mm to avoid soil sealing due to droplet impaction. The control of the particle size distribution is achieved through the combination of nozzle size, defector's canal shape and rotation velocity. Designing prototypes and optimizing the shape of this innovative sprinkler is an important part of this research. In terms of maintenance and water conditioning the objective to achieve is a long term operation with a filtration of 0.500 mm.

In terms of cost, this technology is a non-complex plastic device, easy to build and costless. Its operating pressure is low thus its setting up will combine noncomplex infrastructure and easiness to use. In terms of environmental impact, the low operating pressure allows to reduce losses of water and to avoid large irrigation installations.

Anti-drift micro-sprinkler

Features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the use with treated WW

The targeted countries have in common a marked water scarcity and a high evaporative climate. The purpose of this technology is first to have the capability to reuse treated wastewater with minimum clogging risk, then to minimize the risk of pathogen dissemination under windy conditions by attaining a droplet size that restricts the potential drift. This, in turn, will decrease the potential evaporation.

Results obtained in MADFORWATER relatively to this technology

The results obtained to date are mainly droplet size distribution along the radius. These data were obtained using a laser-optical disdrometer that counts droplets and estimates their sizes. Measurements show that droplet size range are close to the intended range of diameter. We performed experiments with aquaculture effluents to test this technology with a wastewater characterized by a relevant presence of suspended solids (> 200 mg/L). The analysis of wind impact on water distribution and particle size distribution is in progress.

Specific obstacles relative to the application of this technology with treated WW, in Egypt, Tunisia and/or Morocco

Obstacles to the design of such a micro-sprinkler with high durability and anti-drift properties are related to the selection of materials and proper shape of the deflector to adapt distribution characteristics and resist to fatigue. An experiment is undergoing to evaluate the entity of biofilm formation on various types of plasticized materials.

AN IRRIGATION EMITTER RESISTANT TO CLOGGING

Type of crops "targeted" by this technology

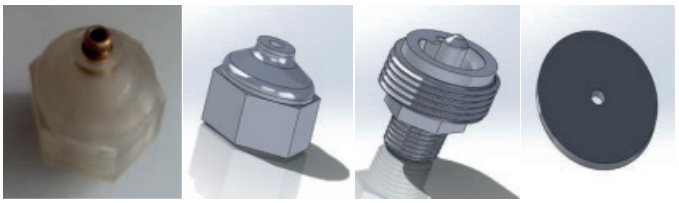
This type of emitter can be used on permanent as well as temporary high value crops, but it is not siutable for cereals and other more extensive crops.

Benchmark technology used in Egypt, Morocco and Tunisia for the irrigation of these crops

This type of emitter is an alternative solution to drip irrigation emitters, as it doesn't require a filtration finer that 1 mm size after decantation of the effluent. This property is obtained by a high discharge, preventing any deposit in the emitter that may lead to clogging and decrease the distribution uniformity and hence the irrigation efficiency. The high discharge that may result in runoff, is balanced by the capacity of the emitter to operate for short cycles (typically one-minute frequent pulses), to deliver the required irrigation application.

Technology description

Depending on the size of the nozzle adjusted to the emitter the discharge ranges from 30 to 100 l/h under a pressure from 0.5 to 2.0 bar. This high discharge will result in instant application rates that overpass the infiltration capacity of most agricultural soils. Consequently the operation is divided in short cycles (typically 1 or 2 minutes) repeated as required. Considering that a 200-m irrigation bloc takes around 1 minute to get filled and pressurized when switched on, an anti-leakage membrane has been added that closes the emitter at a pressure of 0.35 bar. Thus the system pressurization is almost instantaneous, allowing a high distribution uniformity. The pressure regulation propriety of emitter keeps a uniform distribution with a single nozzle size.



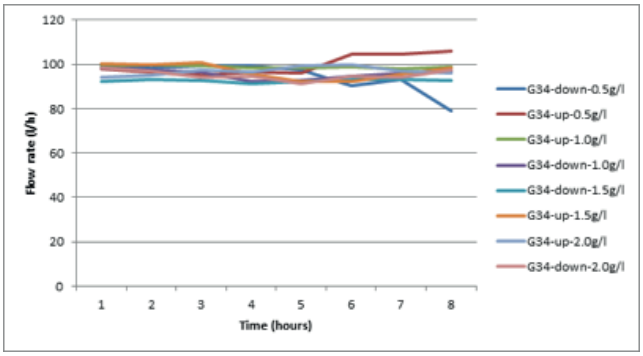
Anti-leakage emitter scheme

Features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the use with treated WW

The main advantage of this technology is its capacity to withstand treated wastewaters with a high content of suspended solids, that normally require the use of fine filtration systems or frequent cleaning solutions when distributed with micro-irrigation drippers. Indeed, these fine filters are simple to use but they require a constant maintenance that many farmers don't respect in the long term. This innovative emitter has been evaluated with suspended solids in the 2 to 4 g/L concentration range, without any relevant clogging phenomena. This indicates that it is suitable for the use with treated wastewaters characterized by high contents of suspended solids.

Results obtained in MADFORWATER relatively to this technology

During the project development the emitter has been designed, prototyped and evaluated experimentally regarding its hydraulic performance and clogging sensitivity with various type of physical contaminants (particles, see graph below, and fibers). The system has been also evaluated in terms of fluid mechanics by numerical simulation. The tests are continuing in laboratory with synthetic effluents, developed so as to reproduce the effluents of the different wastewater types targeted by MADFORWATER. Further tests are planned with real treated wastewater effluents in experimental sites managed by Irstea.



Clogging evaluation with fibers up to a concentration of 2 g/L (50-60 µm diameter) with emitter position up and down

Specific obstacles relative to the application of this technology with treated WW, in Egypt, Tunisia and/or Morocco

The practices related to the use of this type of emitter are different from those relative to the existing drip irrigation systems. A time for adaptation is necessary that will have to be documented during the last year of the project. The high discharge of this emitter is not suitable for all type of crops, and it may be necessary to change the size of the irrigation pipelines.

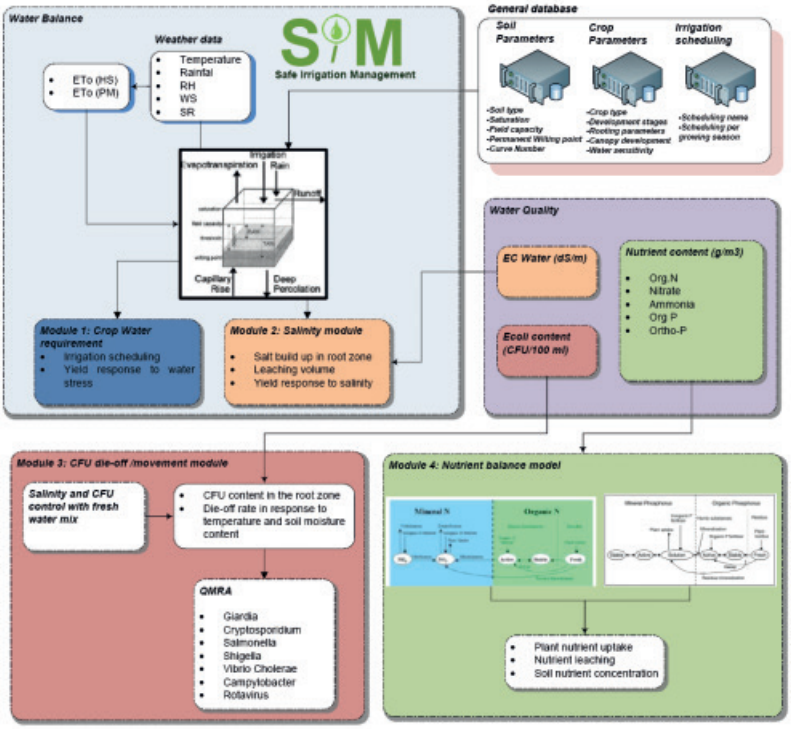
A CONSOLIDATED MODEL TO OPTIMIZE IRRIGATION WITH WATER OF DIFFERENT QUALITIES

Type of crops "targeted" by this technology

The model was tested on several fruit crops (e.g. tomato, potato) and field crops (e.g. wheat, maize).

Technology description

Safe Irrigation Model (SIM) is a daily bucket model used to assess crop water requirement by using freshwater, treated wastewater or mixes water. The model is adapted to various irrigation systems, water of different qualities, different soil types and crop varieties. In the case of treated wastewater, two main parameters are taken into account: i) water salinity and ii) concentration of *E. coli*. The model also allows to assess and control microbial risk.
The model is capable of simulating the annual effects of water irrigation events on physical properties of soils and crop yield.



Safe Irrigation Management (SIM) modules

Features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the use with treated WW

This model supports farmers and decision makers in the identification of the optimal water allocation and management options, including the selection of the optimal water mix. The ability of the model to predict future conditions is very useful for projecting the outcomes of various possible irrigation management strategies.

Results obtained in MADFORWATER relatively to this technology

The SIM model is being applied in the Souss-Massa basin in Morocco, to optimize irrigation scheduling and salt balance of specific crops using different qualities of water. To evaluate the model performance a preliminary test was conducted. The figure reported below shows a typical irrigation scheduling. Irrigation is timed automatically. Once the irrigation timing is set, the volume of water can be automatically applied as: i) fixed amount of water (mm); ii) return to fixed soil moisture deficit (mm); iii) return to fixed soil moisture depletion (% of the soil water holding capacity).

An irrigation schedule obtained from the SIM model

Specific obstacles relative to the application of this technology with treated WW, in Egypt, Tunisia and/or Morocco

- Difficulties in obtaining the required source data
- Difficulties in obtaining the data required to calibrate the model for each specific country
- The use of wastewater is restricted and often allowed only in controlled experiments

INNOVATIVE BIOFERTILIZERS FOR A SUSTAINABLE AGRICULTURE IN NORTH AFRICAN COUNTRIES

Type of crops "targeted" by this technology

Large collection of Plant Growth Promoting bacteria were established from several plant hosts, namely sorghum, alfalfa, argan, olive trees, fig trees and citrus collected in Mediterranean African countries. The best performing strains were selected to conduct in vivo tests using tomato and durum wheat, crops of interests in Mediterranean African countries. In principle, PGP bacteria inocula can be applied to all crops to enhance their growth, productivity and stress resistance.

Technology description

Plant growth promoting (PGP) microbes can support plant growth under harsh conditions typically occurring in extreme environments, such as drought and soil salinity that are the main abiotic stresses limiting crop productivity. However, their application to promote crop productivity is still poorly applied at large scale. MADFORWATER is developing and applying site-tailored PGP inocula as biofertilizers/biostimulants for selected crops of high economical interest for Mediterranean African countries. The selected inocula will be not only endowed with plant-growth activities but also well adapted and efficient in the context of treated WW reuse in stressed and arid lands characteristic of the target countries.

Experimental set-up in greenhouse to test Plant Growth-Promoting Bacteria effects on tomato plants grown under different water regimes

Features that make this technology suitable for the context of Egypt, Tunisia and/or Morocco and for the use with treated WW

In addition to their biofertilization (enhancement of nutrients uptake) and biocontrol (production of antimicrobial and insecticide) activities, PGP bacteria enhance the crop resistance to extreme climatic conditions typical of North Africa (salinity, drought), so as to increase treated water reuse efficiency.

Results obtained in MADFORWATER relatively to this technology

Large bacteria collections were established from different herbaceous and arborous plant species collected in Tunisia, Morocco and Egypt. We identified the bacterial strains and assessed their resistance to osmotic and saline stress and their PGP traits, including biocontrol activity, by means of in vitro tests. We studied in vivo the growth promotion of the best performing strains under greenhouse conditions using tomato and durum wheat, applying different irrigation conditions such as the use of treated WW and the artificial induction of water stress. Our results allowed the identification of different PGP strains of interest as promising candidates to setup biofertilizers adapted to the climatic conditions typical of North African countries.

Specific obstacles relative to the application of this technology with treated WW, in Egypt, Tunisia and/or Morocco

- Lack of the technology vulgarization and large scale production in Egypt, Tunisia and Morocco
- Lack of awareness among the farming community about biofertilizers' properties
- Lack of regulation and standards for biofertilizer production and commercialization
- Need to clearly regulate the ethical and safety issues

INCREASING THE EFFICIENCY OF TRADITIONAL SURFACE IRRIGATION SYSTEMS IN EGYPT

Type of crops "targeted" by this technology

Field crops.

Irrigation technology mainly used in Egypt for the irrigation of these crops

In the Nile delta in Egypt, open channels (called Mesqas) convey irrigation water to quaternary farm ditches called Marwas whichfeed over-irrigated fields. The resulting drainage water irrigates downstream fields, or it is mixed to fresh water and re-enters the distribution system. Consequently, a very high efficiency is achieved at basin level, at the detriment of the quality of water released into drainage canals.

Technology description

The core idea of this technology consists in the conversion of Mesqas and Marwasinto optimized pressurized pipes, equipped with hydrants that supply water to downstream gated pipes, provided with calibrated nozzles and feeding fields furrows. This distribution system allows to maintain in the long term water delivery efficiency, to reduce drainage volumes and therefore, to improve water quality in favor of a greater quantity of fresh water available upstream.

Features that make this technology suitable for the context of Egypt

No water pre-treatments are needed for the application of this technology. In the context of Egypt this technology applies to both irrigation and drainage water.

Results obtained in MADFORWATER relatively to this technology

To minimize energy and maintenance cost, the localized system design was adapted to operate at low pressure (around 0.5 bar). The high discharge rate of the proposed nozzles largely reduce emitters fouling and clogging, problems commonly encountered when irrigating with poor water quality. Particular attention was dedicated to the integration of elastomeric membranes in the nozzle, so as to develop pressure-compensating emitters characterized by a high level of discharge uniformity along the pipe.

Pressure (Bars)	Discharge (L/s)
0.15	0.75
0.2	0.8
0.4	0.84
0.5	0.89

Gated pipe with detail of a calibrated nozzle

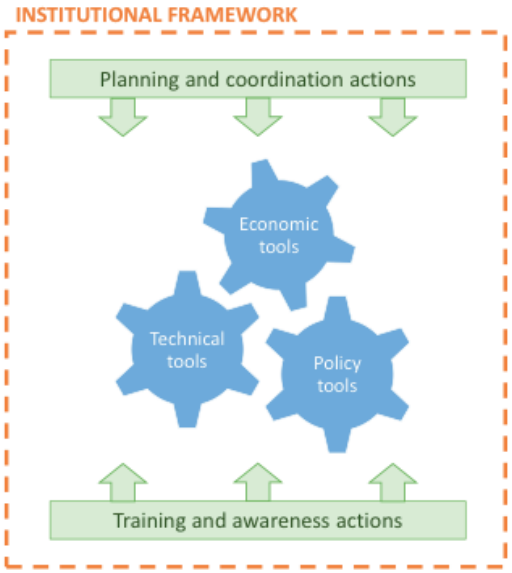
Specific obstacles relative to the application of this technology in Egypt

The main obstacle might be related to the farmers' acceptance to adapt to the use of a technology which substitutes an old and consolidated flooding system approach.

The use of economic instruments in water management in Egypt, Morocco and Tunisia

A specific MADFORWATER task was dedicated to the assessment of the use of economic instruments in water management in Egypt, Morocco and Tunisia. The analysis demonstrated that the target countries made considerable advances in the implementation of the principles of Integrated Water Resources Management. However, the performed analysis suggests that there is still substantial room for improvement in terms of water economic instruments and policies to ensure the long-term sustainability of water resources in the Mediterranean African countries countries in MADFORWATER. Particularly, the low implementation of Integrated Water Resources Management in relation to economic principles - low water tariffs, low cost recovery rates and high levels of subsidization- is highlighted. A better definition of water rights, combined with the development of water markets would also significantly contribute to the control withdrawals and improved allocation of the resource. Moreover, the increase in agricultural water efficiency shows essential in a region where agriculture is the main consumer of water. Institutional factors also prove very relevant. Particularly, accountability from policymakers and the establishment of regional agreements able to improve transboundary water management could result very useful in dealing with water scarcity. In addition, further exploiting the potential for desalination and water reuse in the region could be expected to provide a major tool to meet increasing demands.

Finally, it should be taken into account that no instrument works alone. The functioning of economic instruments usually depends on a wide range of factors such as their combination with other regulatory and technical tools, as well as other horizontal elements providing coordination and support – i.e. planning and coordination bodies and strategies, awareness raising actions or adequate training of human resources.



Main instruments for agricultural water management

Source: Own elaboration based on: Plan Bleu – GWP, 2012. "Water Demand Management - The Mediterranean Experience", No. 1. Global Water Partnership Technical Focus Paper.

Upcoming relevant dissemination events

7TH EUROPEAN BIOREMEDIATION CONFERENCE (EBC-VII) AND THE 11TH INTERNATIONAL SOCIETY FOR ENVIRONMENTAL BIOTECHNOLOGY CONFERENCE, CHANIA, GREECE, JUNE 25-28, 2018

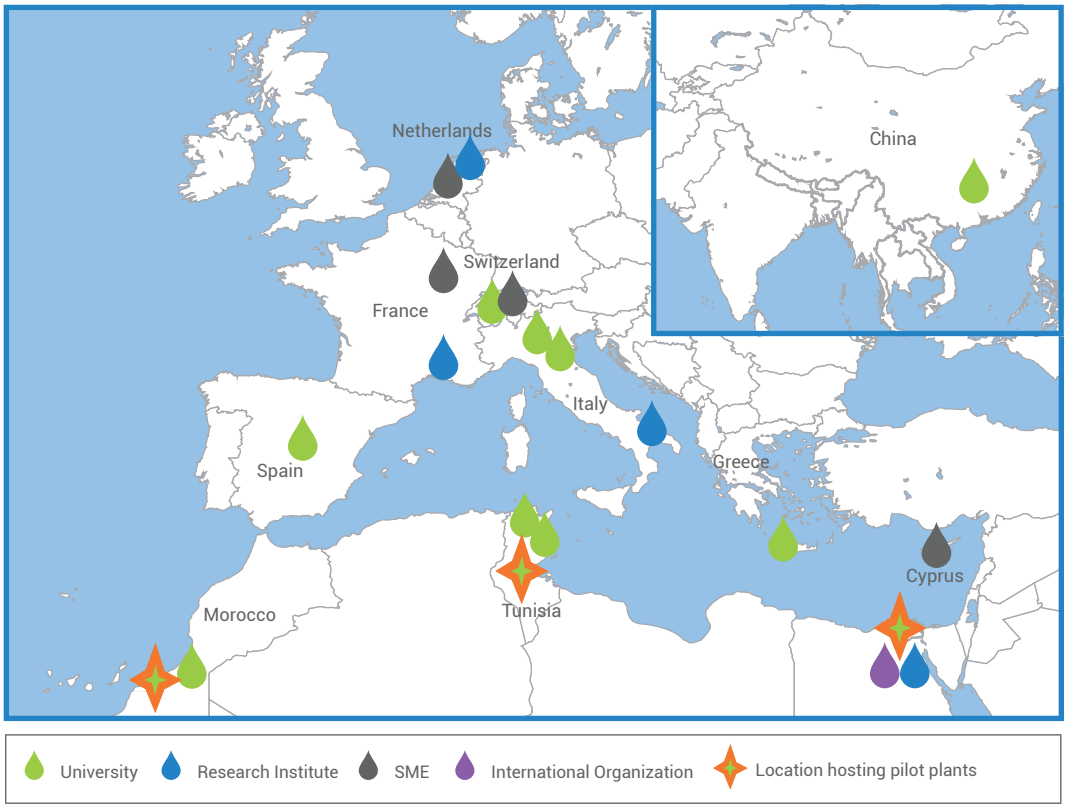
In the framework of the joint VII European Bioremediation Conference and 2018 Conference of the International Society for Environmental Biotechnology (Chania, Greece, June 25-28, 2018; http://www.ebc-vii.tuc.gr/en/home/), MADFORWATER organized two special sessions dedicated to the presentation of the main outcomes of the 7 "Water for Africa" projects financed by the European Commission in the framework of the Horizon 2020 calls Water-5b-2015 "A coordination platform" and Water-5c-2015 "Development of water supply and sanitation technology, systems and tools, and/or methodologies": AFRIALLIANCE, DAFNE, FLOWERED, MADFORWATER, SAFEWATERAFRICA, VICINAQUA and WATERSPOUTT. These two special sessions will represent a unique opportunity to enhance the dissemination of the outcomes of these projects and to explore possible synergies between them.

INTERNATIONAL CONFERENCE "MANAGING WATER SCARCITY IN RIVER BASINS: INNOVATION AND SUSTAINABLE DEVELOPMENT", AGADIR (MOROCCO), OCTOBER 4-6, 2018

The IAV Hassan II Institute - the MADFORWATER partner from Morocco - is organizing the International Conference "Managing Water Scarcity in River Basins: Innovation and Sustainable Development", that will take place in Agadir (Morocco) on October 4-6, 2018. The conference aims at bringing together scientists and practitioners in the water sector to inform exchange and raise awareness about latest knowledge and innovation in areas most affected by water scarcity. It will also highlight European and national Southern Mediterranean strategies on water, and will elaborate on innovations on water reuse from municipal wastewater treatment, the use of brackish water, seawater desalination, water efficiency and reuse in agriculture and will discuss decentralized solutions for sustainable development. This conference will represent an important occasion for the presentation of results from the MADFORWATER and GLOBAQUA research projects. The conference chair will be prof. Redouane Choukr-Allah. The deadline for abstract submission is August 15, for both oral and poster presentations. The conference will include a workshop dedicated to the presentation of the innovative technologies developed by MADFORWATER for wastewater treatment and irrigation.

The MADFORWATER consortium

The MADFORWATER consortium consists of 18 partners geographically distributed mainly around the Mediterranean Sea in 7 European countries, 3 MACs and China. It comprises 9 universities, 4 research centers, 1 international non-profit organization (FAO), 1 consultant and SME expert of marketing, business plan development and innovation management and 3 SMEs in the fields of WW treatment and irrigation. The MADFORWATER partners have a multi-disciplinary expertise that includes wastewater treatment, irrigation, life cycle analysis of technologies, cost benefit analysis of technologies, water vulnerability analysis, stakeholder involvement, integrated water management, capacity building, business plan development.



For more info about the project visit the MADFORWATER website at: www.madforwater.eu

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*If you do not wish to receive future updates or newsletters on the MADFORWATER project, please write to the following email address info@madforwater.eu specifying "**unsubscribe MADFORWATER**" in the subject.*

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