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MADFORWATER

MADFORWATER focused on the 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

Introduction

The MADFORWATER research and innovation project, started in June 2016, aimed 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 focused 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 was combined to the definition of integrated water management strategies, tailored to the local context of selected hydrological basins in Egypt, Morocco and Tunisia.

This leaflet summarizes some of the key findings of MADFORWATER, including:
- an innovative approach for the analysis of water security in the North African context;
- two MADFORWATER Decision Support Tools for the development of strategies for wastewater management and for water management in agriculture;
- the main results delivered by the four pilot plants of wastewater treatment and wastewater reuse for irrigation.

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An innovative approach for the assessment of water security in North African countries

With food demand increasing and consumption patterns changing, agricultural development plays an important role in the economies of the Mediterranean African Countries (MACs). Although these countries face common challenges in their strategy to improve food security, MACs are characterized by interesting opportunities for agricultural development. To better understand the current and future water-related issues and the capacity of society to cope with them, the MADFORWATER project partners developed an innovative Water Security assessment for three North African countries targeted by MADFORWATER: Morocco, Tunisia and Egypt.

The aim of the water assessment was to link project results to the current international debate, with a main focus on the key economic dimension. This dimension was based on the performance of four indexes: the more general Water Resources Index and the sector-specific Agriculture, Energy and Industry Indexes.

The assessment resulted in a relatively low Economic Water Security for the three targeted countries and revealed that as a result of the high storage capacity of surface water in these regions, the risk of water shortage related with rainfall variability and droughts is limited. Future Water Security could however be hampered by the large inter and intra-annual rainfall variability, coupled to a high-water exploitation. The assessment indicates a potential increase in vulnerability for the near future, as the expected reduction of water availability could jeopardize the satisfaction of the future water necessities.

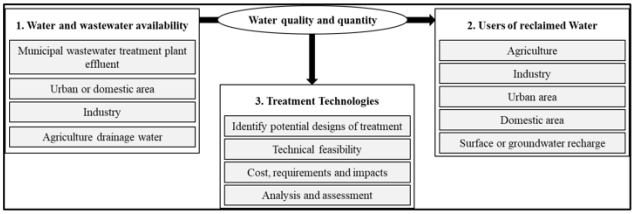
The MADFORWATER water security assessment proved a powerful tool to understand the water related issues and hazards of a specific area. It combines the information provided by several sources into a grouped and standardised value. This approach, that could be used for awareness raising at different levels, from citizens to policy makers, represents the key to initiate measures and to derive policy instruments to improve water security. When this approach is applied on a broader geographic scope, it also allows to compare the water related situation of various regions. Similarly, when a water security assessment is developed on a regular basis, the effect of different policies on the evolution of water security can be assessed. In this way, countries can secure their future food supply.

The MADFORWATER methodology for the analysis of water security at national and basin level in the North African context is freely accessible to any interested stakeholder through public documents deposited in the AMS Acta repository: http://amsacta.unibo.it/6085/.

Decision Support Tool for the establishment of wastewater management strategies

To pre-assess wastewater reuse feasibility for various cases with high potential for water reuse, MADFORWATER partner University of Applied Sciences and Arts Northwestern Switzerland developed a robust decision-support tool (DST), allowing non-expert users to obtain top-ranking technology options, including cost of treatment and quality compliance. The main application is to conduct pre-feasibility studies and assessments, but the DST can also be applied for capacity building at universities and for practitioners.

The DST's purpose is to identify technology options that can treat wastewater to the desired quality for several representative case studies. Using provided information about the wastewater to be reclaimed, the desired reclaimed water quality, and local cost information, the DST automatically proposes top ranking technology options from a database of benchmark treatment trains (series of unit processes) based on lifecycle treatment costs and/or based on a weighting profile defined by the user. It currently encompasses 37 units processes combined into 70 benchmark treatment trains. The DST focuses on the pre-feasibility stage and considers potential water reuse schemes in a systemic approach. This allows determining if an identified area with potential for water reuse could lead to a feasible reclamation scheme with current resources, technologies and available information.



Water reuse for pre-feasibility in a systemic approach: (1) wastewater for reuse, (2) type of intended reuse, (3) identification and assessment of technology.

In the frame of the MADFORWATER project, the DST has been adapted to the specific cases of Egypt, Morocco, and Tunisia, by including country-specific data and information. The added data include typical wastewater qualities, national regulations on water quality requirements for the compliance with different types of reuse, ISO 16075 guidelines for treated wastewater reuse in agriculture and local cost factors. The DST goes beyond technical considerations and includes a multi-criteria analysis consisting in six thematic subjects, namely economy, water management, policy, institution, legislation and environment.

The wastewater management DST is freely available to any interested stakeholder and can be downloaded from the MADFORWATER project website (www.madforwater.eu) or through the Zenodo repository: http://doi.org/10.5281/zenodo.3755380.

Model-based Decision Support Tool for the production of water and land management strategies in agriculture

Another MADFORWATER result was the realisation of an integrated agro-economic model that enables basin authorities and water management agencies to develop strategies for water reuse and water & land management in agriculture. This model-based decision support tool (DST) supports the development of water and land management strategies aimed at (i) an optimal exploitation of the irrigation technologies, and (ii) identifying economic instruments for improving irrigation efficiency and for enhancing treated wastewater reuse in agriculture.

The DST was framed in order to incorporate different types of crops, intensification levels, use of fertilizers, as well as different types of water sources. By identifying the optimal choices of farmers in relation to cultivation and agro-technical models, the model allows to estimate the impact of the adoption of technological innovations and economic and regulatory tools that can be put in place to encourage the reuse of treated wastewater. Several technological scenarios were combined with technological and political scenarios. The proposed DST allows to identify the most efficient scenario for farmers and water managers, in terms of land allocation to different crops, mix of different water types and level of adoption of the different water reuse and irrigation technologies developed in MADFORWATER.

The DST has proven to be essential for the production of water and land management strategies in agriculture for the three case studies (Tunisia, Morocco and Egypt) and has permitted to analyze the impact of irrigation technologies and economic instruments at different levels of aggregation, from farm to basin scale. Built and calibrated on the three case study areas, the model can be utilized in similar agro-ecological and socio-economic contexts. In the presence of conflicting objectives and a multiplicity of stakeholders, this DST is particularly useful in complex decisions in the framework of broader water and land management strategies that countries could implement to ensure the long-term sustainability of the water resource.

The DST for water management in agriculture is freely available to any interested stakeholder through the AMS Acta repository of the University of Bologna: http://amsacta.unibo.it/6444/

Scale-up and validation of the MADFORWATER technologies: the pilot plants of integrated wastewater treatment and agricultural reuse

The MADFORWATER project developed at laboratory scale a wide range of technologies for the treatment and agricultural reuse of several wastewater (WW) types characterized by a relevant production in North African countries: municipal WW, textile WW, olive mill WW, fruit packaging WW and drainage canal water, a mixture of drainage irrigation water and municipal WW typically used for irrigation in the Nile Delta. A significant effort was dedicated to the adaptation of these technologies to the specific context of Tunisia, Egypt and Morocco.

During the second part of the project, a selection of these technologies were scaled up and validated by means of four pilot plants in which wastewater treatment and agricultural reuse of the treated water were effectively integrated. The selection of the technologies to be scaled up based on their technical performances, cost-benefit analysis, life cycle assessment and stakeholder consultation. Municipal wastewater, textile wastewater and drainage canal water were treated and reused in the MADFORWATER pilots.

Integrated pilot plants for municipal wastewater treatment and agricultural reuse.
Two pilot plants were constructed and run for the purpose of municipal wastewater (MWW) treatment and reuse in Tunisia and Morocco.

• The pilot plant (10 m3/d) installed at the Chotrana wastewater treatment plant in Ariana (Tunisia), consisted of a train of (i) a nitrifying trickling filter, (ii) a secondary settler for sludge sedimentation, (iii) a constructed wetland for heavy metals and remaining nutrients removal, (iv) a chemical disinfection unit and (v) an excess secondary sludge dewatering system. Treated MWW generated from the pilot plant was reused for the irrigation of wheat crops and innovative irrigation technologies were tested in the Sidi Thabet pilot: a model for irrigation scheduling specifically designed to take into account the characteristics of treated wastewater (SIM), innovative mini-sprinklers suitable for treated MWW and hot climates and the supply of plant growth-promoting bacteria (PGPB) capable to increase the capacity of specific crops to resist to water deficits. The SIM model together with the user's manual is freely available to any interested stakeholder through the AMS Acta repository of the University of Bologna: http://amsacta.unibo.it/6495/.

• In the Souss-Massa region in Morocco, the pilot plant was based on an the existing M'Zar wastewater treatment plant in Agadir, with a capacity of 75 000 m3/day. The MWW treatment process included an anaerobic lagoon, biodegradation and infiltration on a sand layer, and UV disinfection. Treated MWW produced by the M'Zar plant was used for the irrigation of young olive trees by means of innovative calibrated nozzles. The irrigation water scheduling was performed using the SIM model.

Integrated pilot plant for textile wastewater treatment and agricultural reuse

A textile wastewater pilot plant with a capacity of 10 m3/d was installed in the GWash textile industry (Nabeul, Tunisia) and consisted of a coagulation/flocculation unit, a primary clarifier tank, an aerobic Moving Bed Biological Reactor (MBBR), a secondary clarifier tank, a sand filter and a dye adsorption column. After preliminary runs, the pilot plant was readapted and coagulation flocculation was applied as a principal treatment prior to the refining processes of adsorption and filtration. The treated textile wastewater was successfully reused for the irrigation of sorghum. The results were encouraging in terms of morphological, physiological and yield parameters. Growth and crop yields were similar between the plots irrigated with treated textile wastewater and those irrigated with freshwater. The low-cost treatment process successfully tested in this pilot plant could potentially be implemented at large scale in the North African context, leading to a marked decrease of the pollutant load associated to textile industries. The treated textile wastewater can be reused for the irrigation of non-food crops, as effectively demonstrated in the MADFORWATER pilot.

Integrated pilot plant for drainage canal water treatment and reuse

The fourth MADFORWATER pilot plant was dedicated to drainage canal water (DCW) treatment and reuse, and was installed near Lake Manzala in Egypt, with a capacity of 250 m3/d. The pilot plant consists of a facultative lagoon and three types of constructed wetlands tested in parallel including: (i) a cascade hybrid constructed wetland, (ii) a sequent hybrid constructed wetland, and (iii) a floating bed constructed wetland. Treated and semi-treated drainage canal water were reused for the irrigation of cotton plants, using gated pipes in a section of the pilot plant and traditional furrow irrigation in another section. In comparison to the surface irrigation system traditionally implemented in the Nile Delta, the calibrated nozzle gated pipe technology led to a 14-23% saving in the amount of irrigation water consumed, without any decrease in cotton yield.

Both the MWW treatment trains tested in the MADFORWATER pilot plants led to the production of high-quality treated wastewater that was successfully utilized for the irrigation of wheat and olive trees. For both treatment trains, the overall cost of wastewater treatment was acceptable in the Tunisian and Moroccan context. In particular, the trickling filter / constructed wetland combination appears to be highly suitable for small rural communities (1000-10000 people) currently characterized by a complete lack of MWW treatment and by a lack of irrigation-quality freshwater. Further research is needed to assess the effectiveness of such treatment sequence for the removal of viruses, pathogen bacteria and emerging pollutants.

THE MADFORWATER CONSORTIUM

The MADFORWATER consortium consists of 17 partners geographically distributed mainly around the Mediterranean Sea in 7 European countries, 3 MACs and China. It comprises 9 universities, 4 research centres, 1 international non-profit organization (FAO), 1 consultant and SME expert of marketing, business plan development and innovation management and 2 SMEs active 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, send an e-mail tot Dario Frascari or Marijn Mulder.

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