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Fostering the non-conventional water re-use in agriculture in Mediterranean countries: the MENAWARA project

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Abstract. The Mediterranean region is considered as one of the world's most water-stressed areas where some countries have less than 1000 m^3 $capita^{-1}$ $year^{-1}$. This situation, exacerbated by climate change, is due to, but not restricted to, the relatively uneven distribution of precipitation, high temperatures and increasing water demand, especially for agricultural purposes. Under this context, the use of Non-Conventional Water (NCW), as drainage and treated wastewater, is one of the most sustainable alternatives to cope with water shortage.
The MENAWARA project is designed to enhance access to water through the treatment of wastewater to be reused as complementary irrigation and to strengthen the operational capacity of stakeholders of the quadruple helix, including local farmers, in 8 intervention areas of Palestine, Jordan, Tunisia, Spain and Italy. The actions will reduce the stress on freshwater sources from the agriculture sector and will improve the quality of treated wastewater in agriculture. Clean and environmentally friendly technological, managerial, and operational innovation will be applied and results shared among relevant stakeholders. MENAWARA will play an important role in reducing water insecurity by designing the most suitable post-treatment or Managed Aquifer Recharge (MAR) system for each intervention area and by promoting sustainable development in rural areas.

Keywords: Non-conventional water reuse, Waste Water Treatment Plants (WWTPs), Managed Aquifer Recharge, Mediterranean Region

1. Introduction

Global scale water demand will increase by 55%, and around 40% of the world's population will live in water-stressed river basins by 2050. World delays stronger action on climate change will exacerbate these phenomena (OECD, 2020). The Mediterranean region represents a hotspot for climate change that exhibits significant contrasts in its demographic and hydrologic features. Pressures on freshwater resources have given rise in recent decades to a growing gap between supply and demand of water, and to a deterioration in the quality of surface water and groundwater. Mediterranean countries are still torn between old and new water policies that shaped their water shortage experience mostly related to increasing demand and to poor infrastructure and management practices. More than 70% of total water withdrawals are allocated to irrigated agriculture and water losses and leaks during conveyance and distribution, combined with inefficiency and waste in both irrigation and domestic use, are estimated at 45% of total water demand for these two sectors. This situation is aggravated in those rural areas where irrigated agriculture represents the backbone of the social growth and driving force of the economic activity.

In this context, the re-use of Non-Conventional Water (NCW), as drainage water and treated wastewater, represents one of the most sustainable alternatives to manage imbalances between resource availability and demand also contributing to the promotion and implementation of the circular economy concept, not only from the point of view of water availability, but also from that one of nutrient and energy recovery. Agricultural irrigation was, is, and will likely remain the largest reuse water consumer with recognized benefits and contribution to food security (ISO 16075-2, 2015). However, the agricultural sector has to adapt to a scenario of climate change and to the new political and institutional framework, both at national and international level, where a synergy between agricultural policies together with environmental policies and conservation of natural resources is taking place.

MENAWARA "Non-Conventional WAter Re-use in Agriculture in MEditerranean countries" (2019-2022) (http://www.enicbcmed.eu/projects/menawara) is one of

the five Standard Projects implemented in the framework of the 2014-2020 ENI CBC "Mediterranean Sea Basin Programme" and coordinated by the Desertification Research Centre of Sassari University. The joint challenges of MENAWARA consist of providing additional resources for irrigated agriculture by recycling drainage and wastewater, rationalizing water use practices and setting operational governance models in line with national and international plans. Starting from NCW supply technologies and practices already existing in the intervention areas, and accounting for the technical and socio-political constraints (efficiency of plants, acceptance by local communities and banning of some irrigation techniques by governments), sustainable, clean and environmentally friendly solutions to water stress problems have been identified to reduce the pressure on fresh water from the agriculture sector and improve the quality of NCW for its reuse in irrigated agriculture. Two premises are fundamental in MENAWARA: (i) the application of a new important concept in water reuse, the "fit-to-purpose" approach, which entails the production of reclaimed water quality that meets the needs of the intended end-users (WHO, 2006; ISO 16075-2, 2015, EU Regulation 2020/741, 2020) and (ii) the implementation of technological solutions allowing to obtain reclaimed water with the quality required for irrigating crops, always in accordance with the quality standards and regulations established in each intervention country. To improve water quality, minor interventions and pre and post-treatments are being realized in the existing wastewater treatment plants (WWTPs) besides Managed Aquifer Recharge (MAR) systems while water use efficient irrigation strategies and agricultural practices are being adopted.

The action follows a participatory and knowledge-sharing approach, focusing on strengthening innovation capacity of private and institutional engineers and farmers of the target areas, and on sharing the results with public decision makers, thus reinforcing transnational and institutional cooperation. Living labs will be created in the pilot sites where, among others, "green solutions" will be shown to support their adoption at regional/national scale in order to manage water scarcity. The engagement of stakeholders, capacity building actions and dissemination of results are at the core of the MENAWARA strategy aiming at integrating knowledge, facilitating dialogue, and making national planning more resilient to water demand pressures and compliant with the community needs.

MENAWARA is being implemented in 8 intervention areas of 5 Mediterranean countries: Palestine, Jordan, Tunisia, Italy and Spain (Figure 1).

2. Intervention areas

The intervention areas are quite heterogeneous in terms of socio-economic backgrounds, geographic, climatic and geological characteristics. In Beit Dajan (Palestine), Ramtha (Jordan) and Carrión de los Céspedes (Spain), agriculture suffers from limited availability of water. Target areas were also chosen due to farmers' favorable acceptance to use treated wastewater whose use is so far limited due to its low quality and WWTPs' inefficiency. Compared to the other sites featuring 1 target area, in Tunisia the action is being carried out in 4 areas (Korba, Kelibia, Choutrana, Borj Touil) due to the high interest of authorities/farmers to use better quality treated wastewater. In all these intervention areas, reclaimed water will be used for the irrigation of local plots for the cultivation of olives trees, fodders and ornamental and fruits plants. In Italy, the intervention area is the farming district of Arborea (Sardinia), which was identified as a Nitrate Vulnerable Zone (NVZ) in 2005. In this case, the action aims at mitigating groundwater contamination by implementing a MAR system based on the Forested Infiltration Area (FIA) technique, through the use of drainage water as recharge water.

3. Materials and methods

The technological interventions for the 8 intervention sites have been designed according to the following steps:

- Identification of the quality standards and regulations established for the re-use of NCW in agriculture in each intervention country:
  - ✓ Tunisian standard for the use of treated wastewater in agriculture (NT 106- 003 of 18 May 1989) currently under review;
  - ✓ Palestinian Standard PS 742-2015– Treated Wastewater Effluent for Agricultural Purposes;
  - ✓ Jordanian standards for reclaimed domestic wastewater JS 893/2006;
  - ✓ Spanish Royal Decree 1620/2007 on reuse of treated wastewater;
  - ✓ Italian Ministerial Decree (Ministry of the Environment) n. 185/2003, adopted by the Sardinian Region (DGR n. 75/15, 30.12.2008 "Regional Directive on reuse of treated wastewater", modified in 2018: DGR n. 12/2, 6.3.2018).
- Field surveys to assess the efficiency of the selected WWTPs and to characterize the NCW quality according to the national quality indicators.
- Preliminary design of the minor interventions and pre and post-treatments for the selected WWTPs and the FIA system.
- Field and market surveys for the definition of the executive designs and tendering procedures for the implementation of the work.

4. Results

4.1. Minor interventions and pre and post-treatments design

The main characteristics of the technological interventions designed for the existing WWTPs in the project intervention areas are as follows:

- *WWTP Choutrana II* (TN). The treatment system to be implemented is a post-treatment train to the existing secondary clarifiers and control basin, based on a

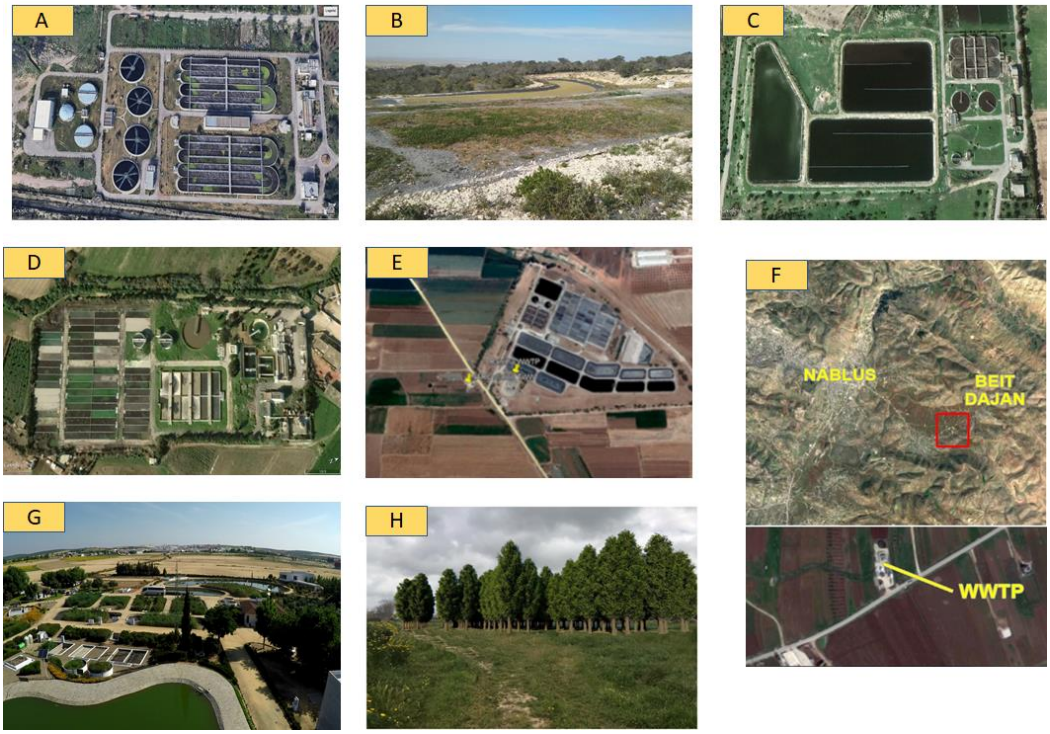

Figure 1. Overview of the location of (8) intervention sites: (A) WWTP Choutrana II-TN, (B) WWTP Borj Touil- TN, (C) WWTP Korba-TN, (D) WWTP Kelibia-TN, (E) WWTP Ramtha-JO, (F) WWTP Beit Dajan- PS, (G) Experimental Center Carrión de los Céspedes-ES, (H) Arborea intervention site-IT.

filtration process using pressure sand filters and a subsequent disinfection stage by application of ultraviolet radiation.

- *WWTP Borj Touil* (TN). In this WWTP, a low-cost treatment train based on two horizontal constructed wetlands (CWs) followed by a maturation pond is already implemented. To avoid that the amounts of sludge that can flow from the existing storage basin upstream can produce clogging in the filter beds, the treatment system to be implemented before the CWs consists of a sedimentation tank.
- *WWTP Korba* (TN). A tertiary treatment line has been designed for the reclamation of the secondary treated wastewater from the WWTP Korba, composed by a filtration treatment through pressure sand filters, after passing the previously treated wastewater through an existing maturation pond. Pressure groups will also be installed to achieve the pressures required by the filtering system (filter stations placed at the plot level).
- *WWTP Kelibia* (TN). The treatment system and interventions are based on the rehabilitation of the existing pumping chamber, implementation of an irrigation pond, pressure group and subsequent sand filtration by pressure sand filters (filter stations placed at the plot level).
- *WWTP Ramtha* (JO). The treatment system to be implemented is a post-treatment train to the existing storage tank, based on filtration process using pressurized sand filters, subsequent disinfection stage by application of ultraviolet radiation and maintenance disinfection by adding sodium hypochlorite.
- *WWTP Beit Dajan* (PS). The current technical status of the plant does not allow the production of treated wastewater according to national parameters thus, requiring minor interventions to sustain its operativity, improve the performance of existing units and the reclaimed treatment processes to be implemented. The designed minor interventions are focused on: by-pass line to relieve excess flow from WWTP; electromagnetic flowmeters to control the process; dissolved oxygen meter in immersion to control and optimize the oxygen supply inside the biological reactor; improvement of chlorination system and water storage tank. Under pre and post-treatment frame, an innovative pre-treatment compact system for screening, sand removal, and degreasing of wastewater has been designed. For water reclamation, a post-treatment train based on a filtration process using pressure sand filters and a subsequent disinfection stage by application of hypochlorite as a disinfecting agent has been designed.
- *Experimental Center of Carrión de los Céspedes* (ES). The designed treatment train is based on different kind and configurations of constructed wetlands (aerated, vertical flow, superficial flow), floating macrophytes, followed by a storage pond with ultrasound treatment and pressurized sand filtration. For this intervention site where the reclaimed water will be used for the irrigation of olive trees, the treatment train will be also evaluated according to the new EU regulation 2020/741 for the irrigation of this crop.

4.2. FIA system design

In the Arborea intervention area (IT), a MAR technique based on Forested Infiltration Areas (FIA) will be tested as a best practice to mitigate the groundwater nitrate contamination for the sandy phreatic aquifer. The designed FIA system will be implemented in an area of around 0.4 ha supplied with NCW (drainage water) pumped from an existing dewatering pumping station. The design consists of six parallel recharge trenches placed between rows of white poplar trees (*Populus alba*) and equipped with an innovative Passive Treatment System, consisting of a mixture of inert and organic materials to attenuate organic and inorganic contamination and to prevent clogging processes at the infiltrating surface.

5. Discussion and conclusion

The technological interventions that will be implemented and tested within the MENAWARA project focus on the improvement of the performance of the already existing treatment units to ensure the water reclamation treatment processes. Focusing from the beginning on the production of reclaimed water quality that meets the needs of the intended end-users and is compliant with the quality standards in each intervention area, it is undoubtedly a guarantee for the future. Likewise, designed technological interventions will significantly contribute to improve the agricultural sector taking another step in its process of adaptation to the new political-climate scenario, and to the improvement of well-being of local farmers, backbones of the economic and social development of many rural areas of the Mediterranean countries participating in the MENAWARA project.

Although the expected impact of the pilot FIA system on the sandy aquifer in Arborea will be very localized and it will not be able to definitively solve the issue of the groundwater nitrate contamination, the achieved results will be important to estimate the number of ha of FIA systems to be implemented and to identify the most suitable sites in the whole Arborea NVZ to improve significantly the groundwater quality of the sandy aquifer. FIA systems could thus be integrated into the Sardinia Basin Management Plan as a possible tool to mitigate the quantitative-qualitative degradation of groundwater not only in the Arborea plain but also in similar hydrogeological contexts, thus disseminating this MAR technique to all Mediterranean region thanks to the international network of the MENAWARA project.

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