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MENAWARA

WP3. ACTIONS TO INCREASE THE QUALITY OF NON CONVENTIONAL WATER USED IN AGRICULTURE

Output 3.1. Non-conventional water quality indicators

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1. SCOPE AND OBJECTIVES

The globally water scarcity, particularly important in arid and semi-arid regions such as Mediterranean area, is driving for a high competition for water resources. This creates the need for using so-called 'non-conventional sources' for water, such as low-yielding wells and springs, rainwater, urban runoff, stormwater and greywater, among others. In this frame, water reuse, with guarantees for public health and the environment, has ceased to be a marginal resource to become one of the basic strategies for water resources management and a key asset of any 'circular economy', not just in view of water availability but also nutrient and energy recovery.

Water reclamation and reuse have become an attractive option for conserving and extending available water supply and is a measure towards fulfilling following three fundamental objectives within a perspective of integrated water resources management:

- Environmental sustainability by reducing pollutants load and their discharge into receiving water bodies, and the improvement of the quantitative and qualitative status of those water bodies (surface water, groundwater and coastal waters) and the soils.
- Economic efficiency alleviating scarcity by promoting water efficiency, improving conservation, reducing wastage and balancing long term water demand and water supply.
- For some countries, contribution to food security growing more food and reducing the need for chemical fertilizers through treated wastewater reuse.

Water is reused worldwide, including the Mediterranean area, for various purposes. Globally, agricultural irrigation is the main application for water reuse with 32% of the reclaimed water used for this purpose. This is followed by landscape irrigation (20%) and industrial uses (19%). Recharge of groundwater is one of the least developed global uses with 2% of the reclaimed water being used for this purpose. However, this and various non-potable urban uses, recreational and indirect potable reuse are highlighted as an application with important potential. (EC, 2016, (ISO 16075-1, 2015). More specifically, Table 1 shows the main reclaimed water applications, worldwide.

Table 1. Main reclaimed water applications in the world, including Mediterranean area. (Adapted from NRMMC-EPHC-AHMC, 2006; EPA, 2012; Asano et al., 2006)

Categories of uses	Uses
Urban	Irrigation of public parks, sporting facilities, private gardens, roadsides, street cleaning, fire protection systems, vehicle washing, toilet flushing, air conditioners, dust control, sewer flushing
Agricultural	Food crops not commercially processed, food crops commercially processed, pasture for milking animals, fodder, fibre, seed crops, ornamental flowers, orchards, hydroponic culture, aquaculture, greenhouses, viticulture
Industrial	Processing water, cooling water, recirculating cooling waters, washdown water, washing aggregate, making concrete, soil compaction, dust control
Recreational	Golf course irrigation, recreational impoundments with/without public access (e.g. fishing, bathing), aesthetic impoundments without public access, snowmaking
Environmental	Managed Aquifer Recharge, wetlands, marshes, stream augmentation, wildlife habitat, silviculture
Potable	Aquifer recharge for drinking water use, augmentation of surface drinking water supplies, treatment until drinking water quality

In the frame of MENAWARA project, under WP3 (Actions to increase the quality of non-conventional water used in agriculture), Activity 3.1.1 (Field assessment of the efficiency of the Wastewater Treatment Plants (WWTP) and the quality of non-conventional water), the aim of the report 3.1 is to highlight the quality indicators for non-conventional water in the intervention areas.

Quality indicators have been identified based on National quality standards for water reuse in agriculture and assessed by the Consortium, mutually agreed with the Local Water Authorities of the intervention areas. Likewise, field assessments have been carried out in order to evaluate the technical situation of the 6 WWTPs in Tunisia, Palestine and Jordan, included in the frame of the project, those will allow to determine minor interventions and/or pre-post treatments to obtain quality treated wastewater suitable for the irrigation purposes.

2. WP3. ACTIONS TO INCREASE THE QUALITY OF NON CONVENTIONAL WATER USED IN AGRICULTURE

WP3 aims to assess the efficiency of no. 6 WWTPs in the intervention areas of North Africa and Middle East (Kelibia, Korba, BorjTouil and Choutrana-Tunisia, Ramtha-Jordan and Beit Dajan-Palestine) and to design, under the approach "fit to purpose", implement and test new low-cost pre and post-treatment systems to improve the quality of treated wastewater (TWW) for agricultural purposes. Target areas were chosen due to communities' favorable acceptance to use TWW whose use is so far limited due to its low quality and WWTPs inefficiency. Compared to all target areas, in Tunisia 4 sites will be considered due to the high interest of authorities/farmers to use better quality TWW.

Regarding European Countries, in Spain (Experimental Plant of Carrión de los Céspedes) a low-cost treatment train will be assessed for olive trees irrigation while an improved drainage water will be used to increase groundwater availability for irrigation purposes in Italy, by implementing MAR systems through Forested Infiltration Areas (FIA)

Figure 1. Intervention sites in MENAWARA project: (4) Tunisia, (1) Palestine, (1) Jordan, (1) Spain, (1) Italy

2.1. NON-CONVENTIONAL WATER QUALITY INDICATORS

The aim of the Output 3.1. is to identify the water quality indicators (both physic-chemical as microbiological) for the use of non-conventional water (treated wastewater) for agricultural reuse, according to the existing National standard of quality in the countries joining in MENAWARA project (Tunisia, Palestine, Jordan, Italy and Spain), as well as carry out a benchmarking between the 6 National standards; considering that the specifications of each one answer to the need and reality of each area.

2.1.1 WATER REUSE AT EUROPEAN CONTEXT

Over the past thirty years, droughts have dramatically increased in number and intensity in the EU and at least 11% of the European population and 17% of its territory have been affected by water scarcity to date. The Commission expects further deterioration of the water situation in Europe if temperatures keep rising as a result of climate change.

Water scarcity is no longer confined to a few corners of Europe, as the Mediterranean region (Spain, Italy, Portugal, Southern France, Cyprus, Greece and Malta), where about 20% of the population lives under constant water stress increasing up to 50% in summer. Water scarcity is now becoming a concern across the EU. By 2030, water stress and scarcity will probably affect half of Europe´s river basins (http://ec.europa.eu/environment/water/reuse.htm).

In EU, the reuse of treated wastewater must be undertaken in full compliance with the requirements of relevant EU legislation. In this regard, the reuse of treated wastewater has been highlighted within EU water policy as one possible alternative water source in water-scarce regions, which may be appropriate to consider within water-scarcity planning (COM, 2007, 414 in CIS, 2016). It was also identified as a priority in the 2012 Water Blueprint (COM, 2012, 673 in CIS, 2016) and it is also a supplementary measure which Member States can adopt as part of the Programme of Measures required under Article 11(4) of the Water Framework Directive (2000/60/EC). It is a top priority area in the Strategic Implementation Plan of the European Innovation Partnership on Water in http://ec.europa.eu/environment/water/reuse.htm).

Reuse of treated wastewater is further emphasised in EU policy on resource efficiency, most notably in the 2015 Communication on the Circular Economy (COM, 2015, 614 in CIS, 2016) which states "in addition to water-efficiency measures, the reuse of treated wastewater in safe and cost-effective conditions is a valuable but under-used means of increasing water supply and alleviating pressure on over-exploited water resources in the EU".

Council Directive 91/271/EEC concerning urban waste water treatment was adopted on 21 May 1991 to protect the water environment from the adverse effects of discharges of urban waste water and from certain industrial discharges. On 27 February 1998, the Commission issued the Directive 98/15/EC amending the Directive 91/271/EEC to clarify the requirements of the Directive in relation to discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication.

Water quality requirements for discharges from urban WWTPs are as follows:

Table 2. Requirements for discharges from urban wastewater treatment plants. The values for concentrations or for the percentage of reduction shall apply. (Adapted from Directive 91/271/EEC).

Parameters	Concentration (mg/L)	Minimum percentage of reduction
BOD_5	25	70-90
COD	125	75
TSS	35	90
Note: analyses concerning discharges from lagooning shall be carried out on filtered samples; however, the concentration of TSS in unfiltered water samples shall not exceed 150 mg/l.		

Requirements for discharges from urban waste water treatment plants to sensitive areas, which are subject to eutrophication are as follows, considering that one or both parameters may be applied depending on the local situation and that the values for concentration or for the percentage of reduction shall apply:

Table 3. Requirements for discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication (COMMISSION DIRECTIVE 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC with respect to certain requirements established in Annex I thereof)

Parameters	Concentration	Minimum percentage of reduction
Total phosphorus	2 mg/L (10,000-100,000 p.e)	80

	1 mg/L (more than 100,000 p.e)	
Total nitrogen	15 mg/L (10,000-100,000 p.e) 10 mg/L (more than 100,000 p.e)	70-80

The European Commission has been working for years on a harmonized proposal of minimum requirements for water reuse in member countries. This proposal is part of the Action Plan to promote the Circular Economy, considering that water reuse has a lower environmental impact than water transfers and desalination and that, without a doubt, will improve water availability and promote its efficient use. Currently, only 6 countries have regulations in this regard (Cyprus, Italy, France, Portugal, Greece and Spain).

SPAIN

Wastewater discharge

In Spain,the requirements for discharges from urban WWTPs, including also the discharges to sensitive areas which are subject to eutrophication are both included in the previous Tables 2 and 3 (according to Directive 91/271 and Commission Directive 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC with respect to certain requirements established in Annex I thereof.

Wastewater reuse for agricultural irrigation

Regarding to the quality standards of reclaimed waters, they are based on their end use according to the Royal Decree 1620/2007, establishing the legal regime of water reuse in Spain. It was an important step in the regulation of wastewater reuse by clarifying the responsibilities of (i) public administrations; (ii) authorized dealers; (iii) end users, etc. In addition, this regulation fixed quality standards for each possible use of these flows.

Spanish Royal Decree 1620/2007 allows the reuse of treated wastewater in the following (5) uses: urban, agricultural, industrial, recreational and environmental. Regarding the agricultural irrigation, it is allowed for the following crops:

- Crops irrigation using a system whereby reclaimed water comes into direct contact with edible parts of crops to be eaten raw.

- Irrigation of crops for human consumption using application methods that do not prevent direct contact of reclaimed with edible parts of the plants, which are not eaten raw but after and industrial treatment process
- Irrigation of pasture land for milk or meat producing animals
- Localized irrigation of tree crops whereby reclaimed water is not allowed to come into contact with fruit for human consumption.
- Irrigation of ornamental flowers, nurseries and greenhouses whereby reclaimed water do not come into contact with the crops.
- Irrigation of industrial non-food crops, nurseries, silo fodder, cereals and oilseeds.

Table 4. Required quality criteria for the reuse of treated wastewater in agricultural irrigation (Spanish Royal Decree 1620/2007).

AGRICULTURAL USES[1]	**MAXIMUM ACCEPTABLE VALUE (MAV)**				
	Intestinal nematode (egg/10L)	***E. coli* (CFU/ 100 mL)**	**TSS (mg/L)**	**Turbidity (NTU)**	**Other criteria**
QUALITY 2.1[2] a)Crop irrigation using a system whereby reclaimed water comes into direct contact with edible parts of crops to be eaten raw.	1	100	20	10	Other contaminants included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. *Legionella spp.* 1,000 CFU/L (if there is a risk of aerosolization). It is compulsory to conduct detection tests for presence-absence of pathogen (*Salmonella*, etc.)

					when results repeatedly show that c=3 for M=1,000.
QUALITY 2.2 a) Irrigation of crops for human consumption using application methods that do not prevent direct contact of reclaimed water with edible parts of the plant, which are not eaten raw but after an industrial treatment process. b) Irrigation of pasture land for milk- or meat-producing animals.	1	1,000	35	No set limit	Other contaminants included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. *Taenia saginata*and *Taenia solium*: 1 egg/L (when irrigating pasture land for milk-or meat-producing animals). It is compulsory to conduct detection tests for presence-absence of pathogen (*Salmonella*, etc.) when results repeatedly show that c=3 for M=1,000.
QUALITY 2.3 a) Localized irrigation of tree crops whereby reclaimed water is not allowed to come into contact with fruit for human consumption. b) Irrigation of	1	10,000	35	No set limit	Other contaminants included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of

ornamental flowers, nurseries and greenhouses whereby reclaimed water does not come into contact with the crops. c) Irrigation of industrial non-food crops, nurseries, silo fodder, cereals and oilseeds.					reclaimed water must comply with environmental quality standards. Legionella spp. 100 CFU/L

[1] Reclaimed water characteristics that require additional information: Conductivity, 3.0 dS/m; Sodium Adsorption Ratio (SAR), 6; Boron, 0.5 mg/L; Arsenic, 0.1 mg/L, Beryllium, 0.1 mg/L; Cadmium, 0.01 mg/L; Cobalt, 0.05 mg/L; Chrome, 0.1 mg/L; Copper, 0.2 mg/L; Manganese, 0.2 mg/L; Molybdenum, 0.01 mg/L; Nickel, 0.2 mg/L; Selenium, 0.02 mg/L; Vanadium, 0.1 mg/L. The following formula should be used to calculate the SAR (a dimensionless value, indicated by translators): $SAR = \frac{[Na]}{\sqrt{\frac{[Ca]+[Mg]}{2}}}$

[2] If there is risk of water aerosolization, the conditions of use stipulated on a case-by-case basis by public health authorities must be followed; otherwise, such uses will be not authorized.

[3] When n= number of aliquot samples analyzed; m= (MAV) maximum acceptable value for the bacterial count; M= maximum permitted value for the bacterial count (MAV + Maximum Deviation Limit); c= maximum number of aliquot samples whose bacterial count falls between “m” and “M”.

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