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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. NATIONAL STANDARDS FOR WATER REUSE IN TARGET COUNTRIES (PALESTINE)

PALESTINE

In Palestine, the use of treated wastewater for agricultural irrigation is regulated by the Palestine Standard PS 742-2015-– Treated Wastewater Effluent for Agricultural Purposes. This standard includes the following guidelines:

- The pipe should be used when treated wastewater transfer in soil zones of high permeability and which may affect the groundwater or surface water used for drinking;
- It is not allowed to mix treated wastewater with pure water in the treatment plants to achieve the requirements of standards.
- Irrigation of fruit trees whose fruits are eaten raw should stop one month before the date of their harvest and three weeks before the crops requiring special dealing after the harvest and dispose of fallen fruit and in contact with the ground;
- It is not allowed to use treated wastewater to irrigate all types of vegetables. Quality of treated wastewater should match with properties included in the following Table 3 by final use planned.

Table 2. Categories of treated wastewater according with quality (adapted from Palestine Standard PS 742-2015)

Maximum limits for chemical and biological properties (mg/L) (unless otherwise specified)	Category of Treated wastewater			
	High Quality (A)	Good Quality (B)	Medium Quality (C)	Low Quality (D)
BOD_5	20	20	40	60
TSS	30	30	50	90
COD	50	50	100	150
DO	>1	>1	>1	>1
TDS	1200	1500	1500	1500
pH	6-9	6-9	6-9	6-9
Fat,Oil&Greese	5	5	5	5
Phenol	0.002	0.002	0.002	0.002
MBAS	15	15	15	25
NO_3-N	20	20	30	40
NH_4-N	5	5	10	15
Total-N	30	30	45	60
Cl^-	400	400	400	400
SO_4^{2-}	300	300	300	300
Na^+	200	200	200	200
Mg^{+2}	60	60	60	60
Ca^{+2}	300	300	300	300
SAR	5.83	5.83	5.83	5.83
PO_4-P	30	30	30	30
Al	5	5	5	5
As	0.1	0.1	0.1	0.1
Cu	0.2	0.2	0.2	0.2
Fe	5	5	5	5
Mn	0.2	0.2	0.2	0.2
Ni	0.2	0.2	0.2	0.2
Pb	0.2	0.2	0.2	0.2
Se	0.02	0.02	0.02	0.02
Cd	0.01	0.01	0.01	0.01
Zn	2	2	2	2
CN	0.05	0.05	0.05	0.05
Cr	0.1	0.1	0.1	0.1
Hg	0.001	0.001	0.001	0.001
Co	0.5	0.5	0.5	0.5
B	0.7	0.7	0.7	0.7
FC (Colony / 100 mL)	200	1000	1000	1000
E. coli (Colony/ 100 mL)	100	1000	1000	1000
Nematodes (Eggs/L)	≤1	≤1	≤1	≤1
Temperature (° C) as a maximum	35	35	35	35
The degree of turbidity	5-10	5-10	5-10	5-10

The re-use of treated wastewater in agriculture is allowed as follows:

Without barriers for the following crops: forest trees, pastoral trees during the protection period (Ministry of Agriculture determines the period of

protection), industrial crops such as cotton, fiber brooms, crops grown to produce seeds of agriculture and provision of seeds for watermelon, wood and stone crops that do not have contact with the public, production of herbs that are used in landscaping for sale without public access to the site of production, nurseries and productive plantation and decoration plants.

With barriers: Table (3) in Palestine Standard PS 742-2015-, shows the number & type of barriers. In this sense, some of the barriers are the following:

- A distance of at least 50 cm, above ground, between the drippers and the crop and the fruits, is considered as 2 barriers.
- A distance of at least 25 cm above ground, between the drippers and the crop and the fruits is considered as 1 barrier.
- A distance of at least 50 cm between under-canopy (branches) sprinklers or spray-irrigation, and between the fruits is considered as 1 barrier.
- A plastic groundcover, between the effluent and the fruits, is considered as 1 barrier.
- Subsurface drip-irrigation is considered 2 barriers.

Other barriers are:

- Crop or a fruit with peel or shell inedible is considered 1 barrier
- Crop or a fruit that is eaten cooked only is considered 1 barrier
- Sand filter is considered 1 barrier.
- Treated wastewater detention for a period not less than (15 days) is considered 1 barrier.
- Water pond that contains up to 10% of treated wastewater is considered 1 barrier.
- Disinfection of treated wastewater with chlorine that at least for the remaining chlorine (0.5 mg/L) and the time of contact for at least half an hour or any other method of disinfection is considered 1 barrier.

The following Table 3 shows the required quality for treated wastewater according to some crops, including the number of barriers to be applied.

Table 3 . Quality of treated wastewater and number of barriers for agricultural reuse in some crops (adapted from Palestine Standard PS 742-2015)

CROP	MAXIMUM ACCEPTABLE VALUE								Other criteria/ concerns
	TSS (mg/L)	COD (mg/L)	BOD (mg/L)	Turbidity (NTU)	*E.coli* (CFU/ 100 mL)	Helminths (eggs/L)	FC (CFU/ 100 ml)	No3-N (mg/ L)	
Olive	90	150	60	5-10	1000	≥1	1000	40	Low Quality With 3 Barriers
Citrus	90	150	60	5-10	1000	≥1	1000	40	Low Quality With 3 Barriers
Grapes	30	50	20	5-10	1000	≥1	1000	20	Medium Quality With 2 barriers
Almonds	90	150	60	5-10	1000	≥1	1000	40	Low Quality With 3 Barriers
Fodder Alfalfa	30	50	20	5-10	1000	≥1	1000	20	Medium Quality With 2 barriers

Regarding to irrigation methods, when the use of treated wastewater for irrigation is carried out by sprinklers, there must be a buffer zone between the end of the wet area and the public streets or residential areas or the whereabouts of citizens (waiting station), for example. This distance will depend on the quality of the treated wastewater. Table 4 shows these distances.

Table 4. The quality of treated wastewater and irrigation distance using sprinklers

Water quality	High quality (A)	Good quality (B)	Medium quality (C)	Low quality (D)
Distance/Meter	50	80	120	150

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