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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 to50% 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) 1 mg/L (more than 100,000 p.e)	80
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).

This Regulation (Proposal for a Regulation of the European Parliament and of the Council on Minimum Requirements for Water Reuse,18th December, 2019) lays down minimum requirements for water quality and monitoring, as well as provisions for risk management, for the safe use of reclaimed water in the context of integrated water resourcesmanagement.

The purpose of this Regulation is to guarantee that reclaimed water is safe for agricultural irrigation, thereby ensuring a high level of protection of human and animal health and the environment, promoting the circular economy and supporting adaptation to climate change, contributing to the objectives of Directive 2000/60/EC by addressing water scarcity and the resulting pressure on water resources, in a coordinated way throughout the Union, thus also contributing to the efficient functioning of the internal market.

Some issues to consider in the new Regulation are the following:

> (7). This legal instrument should be flexible enough to allow the continuation of water reuse and at the same time to ensure the possibility for other Member States to apply these rules when they decide to introduce this practice at a later stage.
> (11). It is therefore appropriate to introduce minimum harmonisation by setting minimum requirements for water quality and monitoring. Those minimum requirements should consist of minimum parameters for reclaimed water and other stricter or additional quality requirements imposed, if necessary, by competent authorities together with any relevant preventive measures. The parameters are based on the technical report of the Commission Joint Research Center and reflect the international standards on water reuse.
> (17). Risk management should comprise identifying and managing risks in a proactive way and incorporate the concept of producing reclaimed water of a quality required for particular uses. The risk assessment should be based on key elements of risk management

and should identify any additional water quality requirements necessary to ensure sufficient protection of the environment, human and animal health. For this purpose, the water reuse risk management plans should ensure that reclaimed water is safely used and managed and there are no risks to human and animal health and the environment. In order to develop these risk management plans, existing international guidance or standards such as ISO 20426:2018 Guidelines for health risk assessment and management for non-potable water reuse, ISO 16075:2015 Guidelines for treated wastewater use for irrigation projects or WHO guidelines could be used.

(20). Reclaimed water covered by the requirements of this Regulation is obtained from wastewater that has been collected in collecting systems and that has been treated in urban wastewater treatment plants in accordance with Directive 91/271/EEC and that follows further treatment (either in the urban wastewater treatment plant or in a reclamation facility) to meet the parameters set out in Annex I of this Regulation.

Agricultural irrigation means irrigation of the following types of crops:

- food crops consumed raw, meaning crops which are intended for human consumption to be eaten raw or unprocessed;
- processed food crops, meaning crops which are intended for human consumption not to be eaten raw but after a treatment process (i.e. cooked, industrially processed);
- non-food crops, meaning crops which are not intended for human consumption (e.g. pastures, forage, fiber, ornamental, seed, energy and turf crops).

The classes of reclaimed water quality and the allowed uses and irrigation methods for each class are set out in Table 4. The minimum requirements for water quality are set out in Table 5.

Table 4. Classes of reclaimed water quality and allowed agricultural use and irrigation method (Adapted from Anex I, Council of the EU, 18th December, 2019)

Minimum reclaimed water quality class	Crop category*	Irrigation method
A	All food crops, including root crops, consumed raw and food crops where the edible part is in direct contact with reclaimed water	All irrigation methods

B	Food crops consumed raw where the edible part is produced above ground and is not in direct contact with reclaimed water, processed food crops and non-food crops including crops to feed milk- or meat-producing animals	All irrigation methods
C	Food crops consumed raw where the edible part is produced above ground and is not in direct contact with reclaimed water, processed food crops and non-food crops including crops to feed milk- or meat-producing animals	Drip irrigation** or other irrigation method that avoids direct contact with the edible part of the crop
D	Industrial, energy, and seeded crops	All irrigation methods***

(*) If the same type of irrigated crop falls under multiple categories, the requirements of the most stringent category shall apply.

(**) Drip irrigation (also called trickle irrigation) is a micro-irrigation system capable of delivering water drops or tiny streams to the plants and involves dripping water onto the soil or directly under its surface at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers.

(***) In cases of irrigation methods which imitate rain, special attention should be paid to the protection of the health of workers or bystanders. For this purpose appropriate preventive measures should be applied.

Table 5.Minimum requirements for reclaimed water quality for agricultural irrigation (Adapted from Annex I, Council of the EU, 18th December, 2019)

Reclaimed water quality class	**Indicative technology target**	**Quality requirements**				
		***E. coli* (CFU/ 100 mL)**	**BOD_5 (mg/L)**	**TSS (mg/L)**	**Turbidity (NTU)**	**Other**
A	Secondary treatment, filtration, and disinfection	≤10	≤10	≤10	≤5	*Legionella* spp.: <1,000 cfu/l where there is risk of aerosolization Intestinal nematodes (helminth eggs): ≤1 egg/l for
B	Secondary treatment, and disinfection	≤100	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	
C	Secondary treatment, and disinfection	≤1,000			-	
D	Secondary					

	treatment, and disinfection	≤10,000			-	irrigation of pastures or forage

-The reclaimed water will be considered compliant with the requirements set out if the measurements meet all of the following criteria:

- The indicated values for *E. coli*, *Legionella* spp. and Intestinal nematodes are met in 90 % or more of the samples. None of the values of the samples can exceed the maximum deviation limit of 1 log unit from the indicated value for *E. coli* and *Legionella*spp.and 100 % of the indicated value for intestinal nematodes.

- The indicated values for BOD_5, TSS, and turbidity in Class A are met in 90 % or more of the samples. None of the values of the samples can exceed the maximum deviation limit of 100 % of the indicated value.

A Validation monitoring shall be performed for the most stringent reclaimed water quality class, Class A, to assess that the performance targets (log_{10} reduction) are complied with. Validation monitoring entails the monitoring of the indicator microorganisms associated to each group of pathogens (bacteria, virus and protozoa).

The indicator microorganisms selected are *E. coli* for pathogenic bacteria, F-specific coliphages, somatic coliphages or coliphages for pathogenic viruses, and *Clostridium perfringens* spores or spore-forming sulfate-reducing bacteria for protozoa. Performance targets (log_{10} reduction) for the validation monitoring for the selected indicator microorganisms are set out in Table 6 and shall be met at the point of compliance, considering the concentrations of the raw waste water entering the urban waste water treatment plant. At least 90% of validation samples shall reach or exceed the performance targets.

Table 6. Validation monitoring of reclaimed water for agricultural irrigation (Adapted from Annex I, Council of the EU, 18th December, 2019)

Reclaimed water quality class	**Indicator microorganisms (*)**	**Performance targets for the treatment chain (log10 reduction)**
A	*E. coli*	≥ 5.0
	Total coliphages/ F-specific coliphages/somatic coliphages/coliphages(**)	≥ 6.0
	Clostridium perfringens spores/spore-forming sulfate-reducing bacteria(***)	≥ 4.0 (in case of *Clostridium perfringens* spores) ≥ 5.0 (in case of spore-forming sulfate-reducing bacteria)

(*) The reference pathogens *Campylobacter*, Rotavirus and *Cryptosporidium* can also be used for validation monitoring purposes instead of the proposed indicator microorganisms. The following log10 reduction performance targets should then apply: *Campylobacter* (≥ 5.0), Rotavirus (≥ 6.0) and *Cryptosporidium* (≥ 5.0).

(**) Total coliphages is selected as the most appropriate viral indicator. However, if analysis of total coliphages is not feasible, at least one of them (F-specific or somatic coliphages) has to be analyzed.

(***) *Clostridium perfringens* spores is selected as the most appropriate protozoa indicator. However sporeformingsulfate-reducing bacteria is an alternative if the concentration of *Clostridium perfringens* spores does not allow to validate the requested log10 removal.

Conditions relating to the additional requirements:

Consideration of requirements for water quality and monitoring that are additional to and/or stricter than those specified in Annex I (Council of the EU, 18th December, 2019), when necessary and appropriate to ensure adequate protection of the environment, human and animal health, in particular when there is clear scientific evidence that the risks are originating from reclaimed water and not by other sources.

Depending on the outcome of the risk assessment referred to in point 5, such additional requirements may in particular concern:

(a) heavy metals;

(b) pesticides;

(c) disinfection by-products;

(d) pharmaceuticals;

(e) other substances of emerging concern, including micro pollutants and micro plastics;

(f) anti-microbial resistance.

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