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REGIONE AUTÒNOMA DE SARDIGNA
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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).

ITALY

Wastewater discharge

The national emission standards for wastewater discharge in Italy and Sardinia region are shown in the following Tables 4 and 5, respectively.

Table 4. Requirements for discharge from WWTPs in Italy (D. Lgs. n. 152/2006)

WASTEWATER DISCHARGE			
Identification of National Quality Standard	**ANNEX 5 to Part III (Emission standards for wastewater discharge) of the D. Lgs. n. 152/2006 (Environmental standards)**		
Parameters	Required quality		Other criteria/concerns
	mg/L	%	
	BOD_5: <= 25	BOD_5: 70-90	
	COD: <= 125	COD: 75	
	TSS: <= 35	TSS: 90	
	BOD_5: <= 25	BOD_5: 80	Emission standard for TWWPs of more than 10,000p.e.
	Total P: <= 2	Total P: 80	Emission standard for TWWPs of 10,000-100,000 p.e. which discharge in *sensible areas* (ANNEX 6 to Part III)
	Total N: <= 15	Total N: 70-80	Emission standard for TWWPs of 10,000-100,000 p.e. which discharge in *sensible areas* (ANNEX 6 to Part III)
	Total P: <= 1	Total P: 80	Emission standard for TWWPs of more than 100,000 p.e. which discharge in *sensible areas* (ANNEX 6 to Part III)
	Total N: <= 10	Total N: 70-80	Emission standard for TWWPs of more than 100,000 p.e. which discharge in *sensible areas* (ANNEX 6 to Part III)

Table 5. Requirements for emission standards for wastewater discharge in the Region of Sardinia. (DGR n. 69/25, 10.12.2008)

WASTEWATER DISCHARGE			
Identification of Regional Quality Standard (Sardinia)	**ANNEX 1 (Emission standards for wastewater discharge) of the Wastewater discharge Regional Regulation (DGR n. 69/25, 10.12.2008)**		
Parameters	Required quality		Other criteria/concerns
	mg/L	%	
	BOD_5: <= 60		Emission standard for TWWPs of 50-500 PE
	COD: <= 160		
	TSS: <= 80		
	BOD_5: <= 40		Emission standard for TWWPs of 500-2000 PE
	TSS: <= 60		Emission standard for TWWPs of 500-2000 PE
	Ammonia (NH_4^+): <= 25		Emission standard for TWWPs of 500-2000 PE
	Total P: <= 10		Emission standard for TWWPs of 500-2000 PE

In the Italian intervention site (Arborea, Sardinia), a Managed Aquifer Recharge (MAR) system through a Forested Infiltration Area (FIA) will be implemented by using drainage water as recharge water. According to the Italian legislation, the drainage water is considered as surface water.

The Ministerial Decree n. 100/2016 (Ministry of the Environment, Land and Sea) establishes the criteria for the issue of authorizations for the managed recharge of aquifers for which the use of surface water and groundwater may be allowed (art. 3). In case of use of surface water as recharge water, it must comply with the quality standards as indicated in table 1/A and table 1/B of ANNEX 1 to Part III of the D. Lgs. n. 152/2006 (Environmental standards) (art. 3, comma 2).

The Sardinian Hydrographic District Authority, which is the competent Regional Institution for the issue of authorizations for MAR, will provide the list of parameters from the table 1/A and 1/B to be considered to comply with the quality standards taking into account the specific conditions of the intervention site and the possible contamination sources of drainage water to be used as recharge water.

Water reuse for agricultural irrigation

Regarding the water reuse, the Italian regulation derives from the California guidelines and is included as regulations in the national legislation. This standard refers to the reuse of urban and industrial wastewater effluents.

In the frame of water reuse for agricultural irrigation, reclaimed water could be used for all crops destined for human/livestock consumption and for non-food crops. The use of reclaimed water on crops that might be consumed raw is only allowed in the presence of irrigation systems designed to avoid direct contact of the water with the fruits and edible parts of the crops.

Regarding the irrigation method, the use of sprinkler irrigation systems is prohibited when the recovered wastewater comes into contact with edible parts of the crops. This system can be used in fruit crops with under-head systems as long as there is no contact with the leaves and fruits.

The quality criteria established in the Italian regulation for water reuse in agricultural irrigation are included in the following Table 6.

Table 6. Quality criteria for the use of treated wastewater in agricultural irrigation (Ministerial Decree 185/2003)

WATER REUSE				
Identification of National Quality Standard:	**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 TWW", modified in 2018: DGR n. 12/2, 6.3.2018)**			
INTENDED USE OF WATER: AGRICULTURE IRRIGATION				
	Parameter	Unit	Maximum acceptable value	Other criteria/concerns
No limitations for crops	TSS	mg/L	10	
	BOD_5	mg/L	20	
	COD	mg/L	100	
	E.coli	CFU/100 mL	10	The threshold value 10 CFU/100 mL refers to 80% of the samples, with a maximum value of 100 CFU/100 mL. Note 3. For recovered wastewater from

				lagooning and phytodepuration, the limits are 50 CFU/100 mL (80% of the samples), with a maximum value of 200 CFU/100 mL
	Salmonella		absent	
	pH		6-9.5	Sardinian Region can authorize less restrictive limitations up to 5.5-9.5 (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	SAR		10	
	Coarse materials		absent	
	Electrical conductivity	µS/cm	3000	Sardinian Region can authorize less restrictive limitations up to 4000 µS/cm (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	Al	mg/L	1	
	As	mg/L	0.02	
	Ba	mg/L	10	
	Be	mg/L	0.1	
	B	mg/L	1	
	Cd	mg/L	0.005	
	Co	mg/L	0.05	
	Cr tot	mg/L	0.1	
	Cr VI	mg/L	0.005	
	Fe	mg/L	2	
	Mn	mg/L	0.2	Sardinian Region can authorize less restrictive limitations up to 2 mg/L (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	Hg	mg/L	0.001	
	Ni	mg/L	0.2	
	Pb	mg/L	0.1	
	Cu	mg/L	1	
	Se	mg/L	0.01	
	Sn	mg/L	3	
	Tl	mg/L	0.001	
	V	mg/L	0.1	
	Zn	mg/L	0.5	
	Total cyanides	mg/L	0.05	

	(CN)			
	Free Active Chlorine	mg/L	0.2	
	Sulfides (H_2S)	mg/L	0.5	
	Sulfites (SO_3)	mg/L	0.5	
	Sulphates (SO_4)	mg/L	500	Sardinian Region can authorize less restrictive limitations up to 1000 mg/L (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	Chlorides	mg/L	250	Sardinian Region can authorize less restrictive limitations up to 1200 mg/L (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	Fluorides	mg/L	1.5	
	Total P	mg/L	2	The limits for total P and N can be raised to 10 and 35 mg/L respectively. Regarding the NVZs the provisions of Legislative Decree 152 of 2006 have to be considered
	Total N	mg/L	15	
	Ammonia (NH_4)	mg/L	2	Sardinian Region can authorize less restrictive limitations up to 15 mg/L (Annex 2, Table 2 of the "Regional Directive on reuse of TWW")
	Animal or vegetable fats and oils	mg/L	10	
	Mineral oils	mg/L	0.05	
	Total Phenols	mg/L	0.1	
	Pentachlorophenol	mg/L	0.003	
	Total Aldehydes	mg/L	0.5	
	Tetrachlorethylene, Trichloroethylene	mg/L	0.01	
	Benzene	mg/L	0.001	
	Benzo(a)pyrene	mg/L	0.00001	
	Total Aromatic Organic Solvents	mg/L	0.01	

	Total Nitrogen Organic Solvents	mg/L	0.01	
	Total Surfactants	mg/L	0.5	
	Chlorinated pesticides	mg/L	0.0001	The parameter value refers to each individual pesticide. In the case of Aldrina, Dieldrina, Eptacloro and Eptacloro epoxide, the parametric value is equal to 0.030 µg/Ll
	Organophosphorus pesticides	mg/L	0.0001	
	Other Total pesticides	mg/L	0.05	
	Trihalomethanes	mg/L	0.03	This parameter is considered only in the Regional Directive on reuse of TWW
	Total Chlorinated Solvents	mg/L	0.04	
	Li	mg/L	2.5	This parameter is considered only in the Regional Directive on reuse of TWW
	Mo	mg/L	0.01	This parameter is considered only in the Regional Directive on reuse of TWW

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