European Union Network for the Implementation and Enforcement of Environmental Law

Report on Urban Water Reuse

Integrated Water Approach and Urban Water Reuse Project

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Executive summary: This Report is the result of the work of the subgroup dedicated to the Urban Water Reuse of the "Integrated Water Approach and Urban Water Reuse" project team. It intends to be a first approach to develop a report document on the reuse of treated wastewaters for agriculture irrigation purposes as a tool to achieve the objectives of the Water Framework Directive (WFD) in certain areas and enhancing water management best practices.	
Disclaimer: This report is the result of a project within the IMPEL network. The content does not necessarily represent the view of the national administrations.	

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the EU Member States, acceding and candidate countries of the European Union and EEA countries. The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years, IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 7th Environment Action Programme and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation. Information on the IMPEL Network is also available through its website at www.impel.eu.

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Introduction/aims

More than 15 years after the emanation of several major Directives, including the Water Framework Directive (WFD), Directives on Nitrates, Urban Wastewater Treatment Directive, as well as the Integrated Pollution Prevention and Control Directive (IPPC) now replaced by the Industrial Emissions Directive, their objectives remain to be fully achieved in many Member States.
The reuse of treated wastewater can be an important tool to contribute as a local solution to achieving the objectives of the Water Framework Directive (WFD) and to contribute to a more resource efficient economy as well as to adapt to climate change, namely in cases where water scarcity is identified as a significant pressure.
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.
It was also identified as a priority in the 2012 Water Blueprint 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 WFD.
Reuse of treated wastewater is further emphasised in EU policy on resource efficiency, most notably in the 2015 Communication on the Circular Economy 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”.
The European Commission is working on the development of a legislative proposal for water reuse, for agriculture irrigation and aquifer recharge, namely, considering that there is a lack of harmonization in the regulatory framework at EU level.
A “Proposal for a regulation on minimum requirements for water reuse” has been adopted by the European Parliament and the Council of the European Union on 28th of May 2018.
The exchange of information regarding best practices, safe uses and the permitting process contributes to better compliance of water related regulations and to the increase of confidence of water reuse, in particular for agriculture irrigation practices.

This project is the follow-up of the previous project “Integrated Water Approach” of 2017, extended to the sector of Urban Wastewaters Reuse, i.e., the use of treated urban wastewaters for agriculture irrigation.
The project is carried out by two working groups, related with the urban treated wastewaters reuse and the industrial water management, respectively.
In particular the aim of the first working group is to exchange current best practices with respect to water reuse of treated urban wastewaters for agriculture irrigation purposes.

Current water reuse practice in Europe

Water reuse and recycling has been identified as one of the five top priorities of the European Innovation Partnership (EIP) on Water.

The World Health Organization (WHO) has recognized the main driving forces for global water reuse as:
• increasing water scarcity and stress,
• increasing populations and related food security issues,
• increasing environmental pollution from improper wastewater disposal, and
• increasing recognition of the resource value of wastewater, excreta and greywater (WHO, 2006).

The world's population is becoming increasingly urbanised and concentrated near coastlines, where local freshwater supplies are limited or are available only at great expense. In addition to the need to meet the increasing demands for drinking water supply and other urban demands (e.g. landscape irrigation, commercial, and industrial needs), there is also increased demand for water for agricultural food production due to the greater incorporation of animal and dairy products into people's diets.

An indicator of water scarcity, the Water Exploitation Index (WEI), provides the broadest depiction of water use compared to general availability, and describes the risk posed by over exploitation (Figure 1).

The pressures on water resources have encouraged more active consideration of using alternative water sources as a strategic option to supplement water supplies and protect natural resources.
Water reuse, as an alternative water source, can provide significant economic, social and environmental benefits, which are key motivators for implementing such reuse programmes.
These benefits include:

- Increased water availability
- Integrated and sustainable use of water resources
- Drinking water substitution – keep drinking water for drinking and reclaimed water for non-drinking use
- Reduced over-abstraction of surface and groundwater
- Reduced energy consumption compared to using deep groundwater resources, water importation or desalination
- Reduced nutrient loads to receiving waters
- Reduced manufacturing costs of using high quality reclaimed water
- Increased agricultural production
- Reduced application of fertilisers
- Enhanced environmental protection by restoration of streams, wetlands and ponds
- Increased employment and local economy (e.g. tourism, agriculture)

The report on water reuse by the Water supply and sanitation Technology Platform (WssTP, 2013) notes that "Although investors and water utilities are becoming increasingly enthusiastic about water reuse … the capability of Europe's water sector to deliver reuse projects is being compromised by a lack of suitable regulation, skills and public understanding".
This report also notes that "with appropriate investment in people, knowledge, and technology, Europe could be a global leader in this rapidly developing market", and highlights the "huge eco-innovation potential in terms of technologies and services around water recycling in industry, agriculture and urban water systems". The transition to a circular economy could also promote significant synergies for the wide adoption of water reuse as an alternative water source. The reuse

and recycling of water through an appropriate wastewater management are crucial to a circular economy approach. However, this strategy needs to ensure the safety of the practice by the use of water with an adequate quality that meets the requirements of end-uses with a minimum risk level for human health and environment, which can only be achieved by the use of realible water treatment and delivery systems.

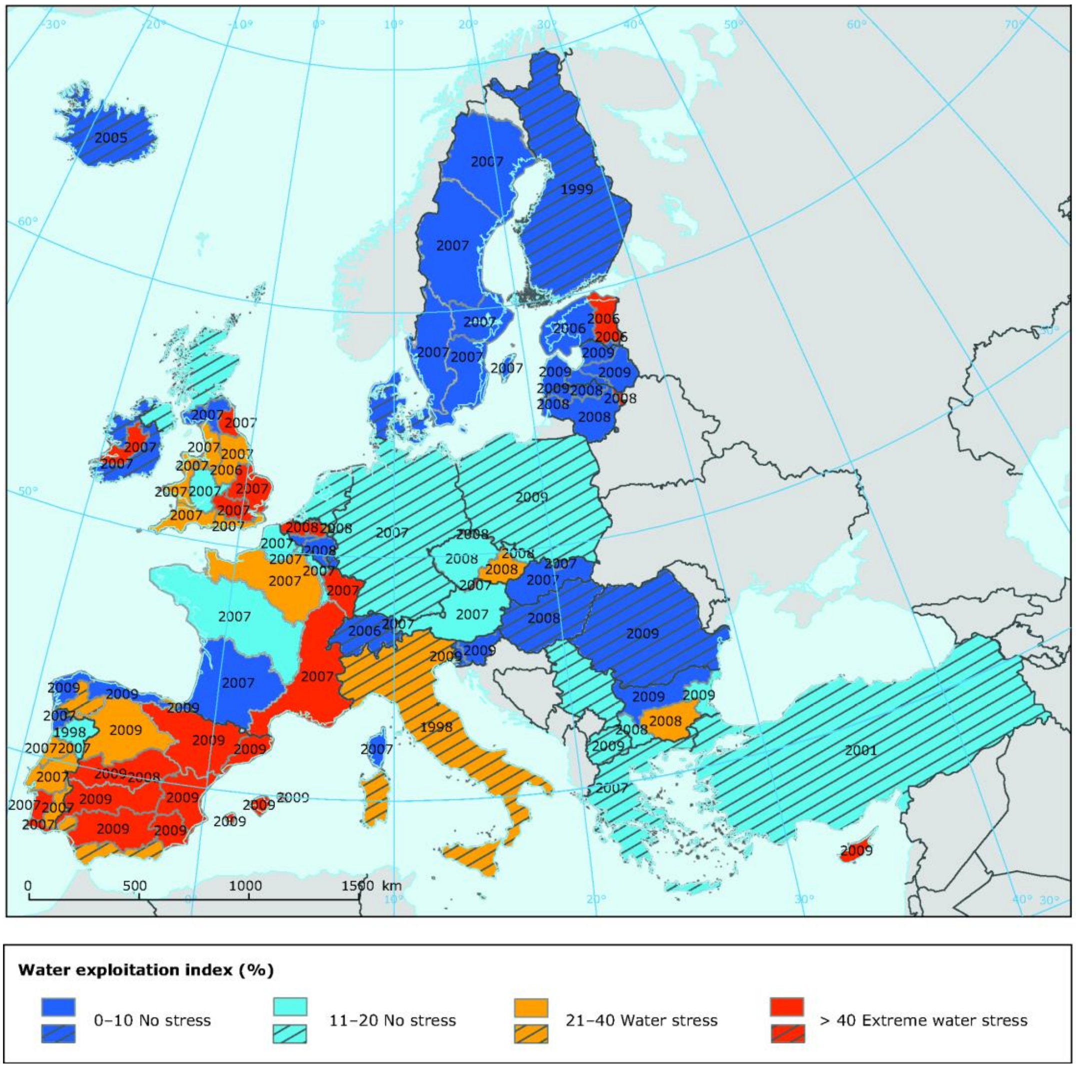

Figure 1 - Water Exploitation Index in Europe in the smallest available data disaggregation (EEA, 2012).

A substantial range of water reuse practices are already applied worldwide, many of these in Europe (Bixio and Wintgens, 2006; GWI, 2010), that bring about significant savings of drinking water. The majority of water recycling schemes are located in Japan (>1800) and USA (>800), followed by Australia (>450), Europe (>200), the Mediterranean and Middle East area (>100), Latin America (>50) and Sub-Saharan Africa (>20). Nowadays, this number is likely to be significantly higher given the rapid development of water reuse in China, India and the Middle East.

In Europe the water recycling schemes are mainly located on coastal areas and islands (in Southern countries) and in highly populated areas (in Northern countries), as represented in Figure 2.
Reclaimed water is primarily used for agricultural, urban irrigation and industrial (Figure 3).

Agricultural irrigation by far is the largest application of reused water worldwide and in Europe and a significant use of water in Europe, overall accounting for around a quarter of total freshwater abstracted. Water reuse in agriculture therefore has the highest potential for an increased uptake of water reuse, thus contributing to the alleviation of water scarcity in Europe.

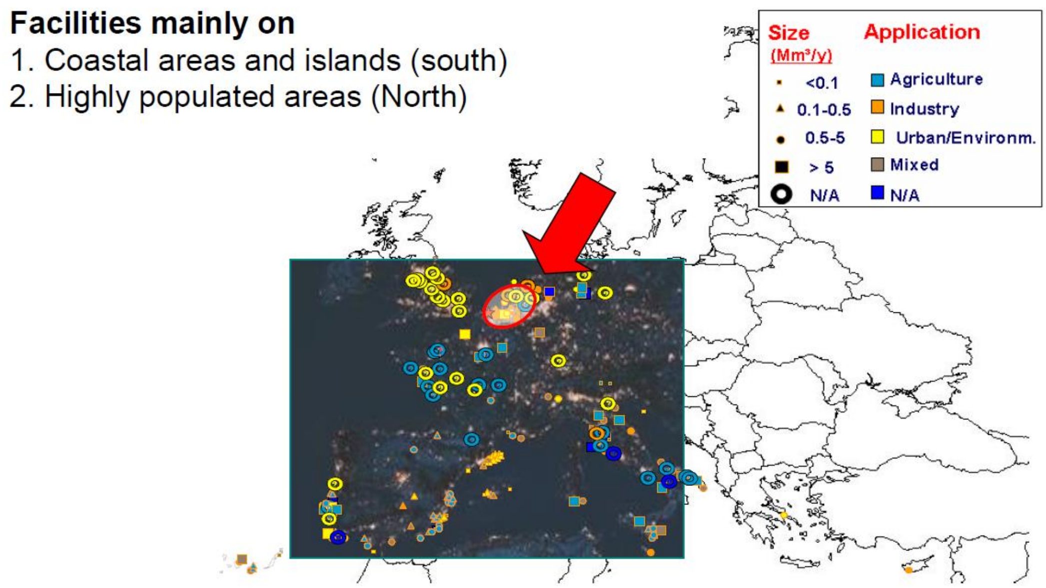

Figure 2 - Geographical distribution of water reuse facilities

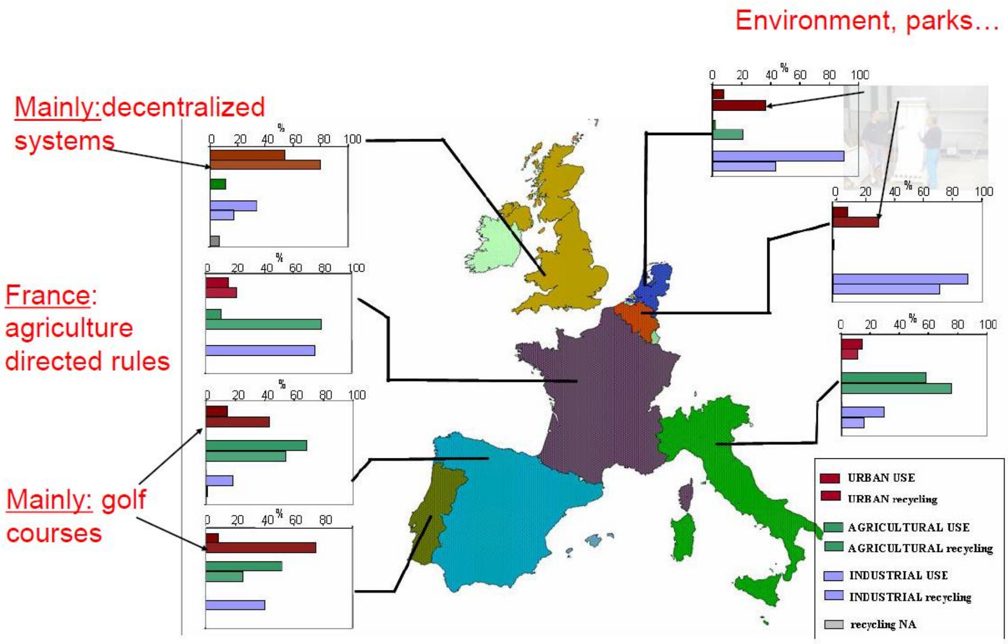

Figure 3 - Water reuse by sectors

Figure 4 shows a model output for water reuse potential of European countries with a project horizon of 2025. Spain shows by far the highest reuse potential, the calculations suggesting a value of over 1 200 Mm³/yr. Italy and Bulgaria both exhibit estimated reuse potentials of approximately 500 Mm³/yr. Water reuse appraisals for Turkey amount to 287 Mm³/yr, whereas Germany and France could potentially reuse 144 and 112 Mm³/yr, respectively.

Portugal and Greece account for reuse potentials of less than 100 Mm³/yr (67 and 57 Mm³/yr, respectively). Overall, the estimates suggest a water reuse potential of 3 222 Mm³/yr (Hochstrat *et al.,* 2005; TYPSA, 2013).

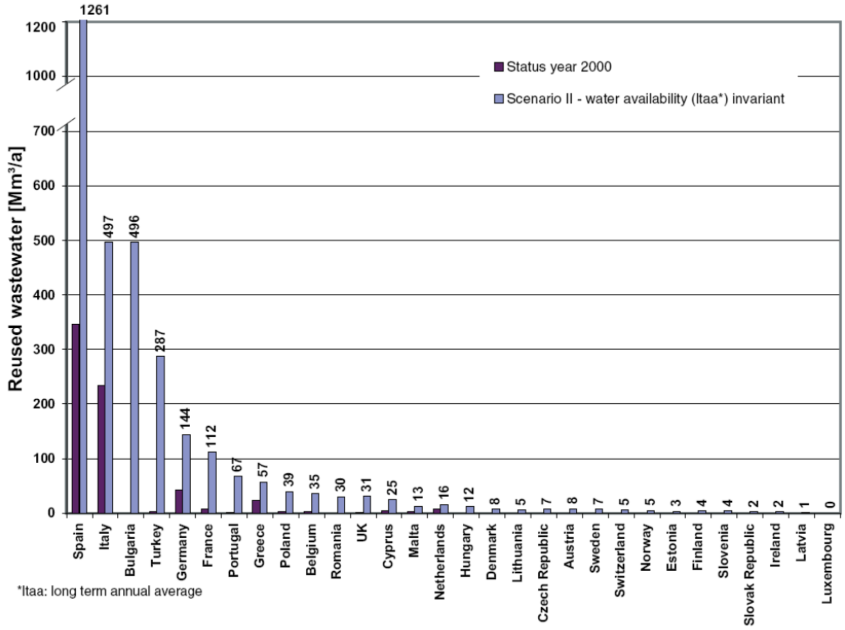

Figure 4 - Model output for water reuse potential of European countries with a projection horizon 2025 (TYPSA, 2013)

However, the use of reclaimed water may present some risks for public health due to its microbiological content and to the environment by the introduction of some contaminants. For instance, currently there is a raise of awarness regarding the the pollutants of emergent concern, namely for aquifer recharge intends. Therefore, to ensure a safe practice a risk management framework is desirable, and has led to the development of guidelines and regulations for the safe use of treated wastewater in an increasing number of countries. Some international and national organizations have developed reference guidelines for water reuse applications (Table 1).

Table 1. Water reuse guidelines developed by international organizations

Organization	Guidelines	Comments
World Health Organization (WHO)	"Guidelines for the safe use of wastewater, excreta and greywater" (2006)	Volume 1: Policy and regulatory aspects. Volume 2: Wastewater use in agriculture. Volume 3: Wastewater and excreta use in aquaculture. Volume 4: Excreta and greywater use in agriculture.
United Nations Environment Programme (UNEP)	"Guidelines for municipal wastewater reuse in the Mediterranean region" (2005) "Development of performance indicators for the operation and maintenance of wastewater treatment plants and wastewater reuse" (2011)	
United Nations Water Decade Programme on Capacity Development (UNW-DPC)	Proceedings on the UN-Water project "Safe use of wastewater in agriculture" (2013)	
International Organization for Standardization (ISO)	ISO/TC282 Water reuse (under development)	The standardisation of water reuse of any kind and for any purpose. It covers both centralised and decentralised or on-site water reuse, direct and indirect reuse, as well as intentional and unintentional reuse. The scope of ISO/PC 253 (Treated wastewater reuse for irrigation) is merged into the proposed new committee. Excluded: the limit of allowable water quality in water reuse, which should be determined by governments, the WHO and other relevant competent organisations.
Food and Agriculture Organization (FAO)	"Water quality for agriculture" (1994)	

It must be noted that some of these guidelines apply to urban wastewater from municipal or other wastewater treatment facilities that have a limited input of industrial waste. The ISO/TC 282 is developing several standard focused on industrial reuse.
Although these guidelines are neither mandatory nor legally binding, their adoption provides a shared objective, and allows for flexibility in responding to different circumstances at regional and local levels.

In Europe, there are no guidelines or regulations at the European Union (EU) level.
Despite of the lack of water reuse criteria at the EU level, several Member States and autonomous regions have produced their own legislative frameworks, regulations, or guidelines for water reuse applications.
The following countries have developed the most comprehensive standards developed specifically for water reuse practices and issued by EU Member States: Cyprus, Greece, Spain, France, Italy and Portugal (Table 2).

Table 2. Most representative standards on water reuse from EU Member States

Country	Standards reference	Issuing institution
Cyprus	Law 106 (I) 2002 Water and Soil pollution control and associated regulations KDP 772/2003, KDP 269/2005*	Ministry of Agriculture, Natural resources and Environment Department of Environment
France	JORF num.0153, 4 July 2014 Order of 2014, related to the use of water from treated urban wastewater for irrigation of crops and green areas	Ministry of Public Health Ministry of Agriculture, Food and Fisheries Ministry of Ecology, Energy and Sustainability
Greece	CMD No 145116 Measures, limits and procedures for reuse of treated wastewater	Ministry of Environment Energy and Climate Change
Italy	DM 185/2003 Technical measures for reuse of wastewater	Ministry of Environment Ministry of Agriculture, Ministry of Public Health
Portugal	NP 4434 2005 Reuse of reclaimed urban water for irrigation	Portuguese Institute for Quality
Spain	RD 1620/2007 The legal framework for the reuse of treated wastewater	Ministry of Environment Ministry of Agriculture, Food and Fisheries, Ministry of Health

* The KDP 269/2005 has been replaced by the Ministerial Decree of small – scale wastewater treatment plants ≤ 2000 p.e (No. 379/2015). Code of Good Agriculture Practice Decree (No. 263/2007). The Water Pollution Control (Discharge of Urban Waste Water) Regulations of 2003 (No. 772/2003) includes the obligations under the UWWTD 91/271/EEC to the national legislation.

The standards of Cyprus, France, Greece, Italy and Spain are included as regulations/ministerial decrees in the national legislation. In Portugal, the standards on water reuse are guidelines, which are usually taken into consideration by the national government when issuing any water reuse permits in the country. However, currently the use of this guideline is being replaced by the ISO standards already published, such as the ISO 16075 – Guidelines for treated wastewater use for irrigation projects.

All the standards evaluated refer to the reuse of urban and industrial wastewater effluents, except the standards of Cyprus and Portugal which refer only to urban wastewater.

As regards Cyprus, the standards refer to the quality requirements for treated water used for irrigation produced from small – scale wastewater treatment plants ≤ 2.000 p.e..

The standards must be carefully compared as there is no homogeneity between the aspects covered by each Member State regulation.

In general, the standards comprise the following criteria:

• Intended uses
• Analytical parameters
• Maximum limit value permitted for each parameter
• Monitoring protocols
• Additional preventive measures for health and environment protection

The intended uses of the standards evaluated are summarised in Table 3.

Most of the standards are intended for agricultural, urban and industrial applications.

Table 3 - Intended uses for water reuse included in the standards of EU Member States

Intended use of reclaimed water	Cyprus	France	Greece	Italy	Portugal	Spain
Irrigation of private gardens						√
Supply to sanitary appliances				√		√
Landscape irrigation of urban areas (parks, sports grounds and similar)	√	√	√	√	√	√
Street cleaning			√	√		√
Soil compaction			√			
Fire hydrants			√	√*		√
Industrial washing of vehicles				√		√
Irrigation of crops eaten raw	√	√	√	√	√	√
Irrigation of crops not eaten raw	√	√	√	√	√	√
Irrigation of pastures for milk or meat producing animals		√	√	√	√	√
Aquaculture						√
Irrigation of trees without contact of reclaimed water with fruit for human consumption	√	√	√	√	√	√
Intended use of reclaimed water	Cyprus	France	Greece	Italy	Portugal	Spain
Irrigation of ornamental flowers without contact of reclaimed water with the product		√	√	√		√
Irrigation of industrial non-food crops, fodder, cereals	√	√	√	√	√	√
Water process, and cleaning in industry other than the food industry			√	√**		√
Water process and cleaning in the food industry			√	√**		√
Cooling towers and evaporative condensers			√	√		
Golf course irrigation	√	√	√	√	√	√
Ornamental ponds without public access			√			
Aquifer recharge by localised percolation	√		√			√
Aquifer recharge by direct injection	#		√			√
Irrigation of woodland and green areas not accessible to the public	✓	√	√	√	√	√
Silviculture						√
Environmental uses (maintenance of wetlands, minimum stream flows and similar)						√

* only for industrial uses.

** reclaimed water cannot be used in direct contact with food, pharmaceuticals or cosmetic products.

In Cyprus, treated effluent is reused for aquifer recharge using recharge ponds but is not covered by the standards. In this case, further monitoring obligations are set up in the Waste Discharge Permits.

The analytical parameters included in the evaluated standards for water reuse are summarized in Table 4. The standards comprise microbiological and physical-chemical parameters.

Regarding microbiological parameters, all the standards include a bacterial indicator to monitor reclaimed water quality, but the selected indicator is not always the same. The regulations of Spain, Cyprus, France, Greece, and Italy have selected E. coli as a surrogate for pathogenic bacteria. In recent years, this indicator has been used to substitute the use of total coliforms and faecal coliforms because it reflects more accurately the behaviour of pathogenic bacteria in water (Ashbolt *et al.,* 2001).

Regarding physical-chemical parameters, all the standards reflect the requirements of several European Directives such as Directive 91/271/EEC on the quality of treated effluent disposal, Directives 2008/105/EC and 2013/39/EU on environmental quality standards, and Directive 91/676/EEC on water pollution from nitrates. In addition to this, some standards include additional parameters or stricter limit values.

Table 4 - Analytical parameters included in the evaluated standards for water reuse

Analytical parameters	Cyprus	France	Greece	Italy	Portugal	Spain
Microbiological parameters						
- *Escherichia coli*	√	√	√	√		√
- Faecal coliforms					√	
- Total coliforms			√			
- Faecal enterococci		√				
- *Legionella* sp.						√*
- *Salmonella* sp.				√		√*
- Sulphate-reducing bacteria		√				
- Helminth eggs (Intestinal nematodes)					√	√
- F-specific bacteriophages		√				
Physical-chemical parameters						
- Total suspended solids (TSS)	√	√	√	√	√**	√
- Turbidity			√			√
- Biochemical oxygen demand (BOD_5)	√		√	√		√**
- Chemical oxygen demand (COD)	√	√		√		√**
- pH	√		√	√	√**	
- Heavy metals and metalloids	√		√	√	√**	√*
- Electrical conductivity (EC)	√		√	√	√**	√*
- Total dissolved solids (TDS)			√		√**	
- Sodium adsorption ratio (SAR)			√	√	√**	√*
- Chlorine (Cl, Chlorides)	√		√	√	√**	√*

Analytical parameters	Cyprus	France	Greece	Italy	Portugal	Spain
- Nitrogen forms (Total, $N-NO_3$, $N-NH_4$)	√		√	√	√**	√*
- Total phosphorus	√		√	√	√**	√*
- Bicarbonate (HCO_3)			√			
- Toxic substances including priority substances			√**	√	√**	√**

* only for certain uses or irrigation methods.

** according to the existing related legislation.

In Cyprus, physical - chemical parameters include also the FOGs, Boron and Residual Chlorine. According to the Ministerial Decree of small – scale wastewater treatment plants ≤ 2000 p.e (No. 379/2015), heavy metals, TN and TP and also all the other parameters specified to Groundwater Directive 2006/118/EC are monitored only for discharges in groundwaters. In this case the frequency is before the discharge and every month during the period of discharge. The limit values are the same with the ones specified in the Groundwater Directive.

The maximum limit values permitted for most of the parameters included in the standards evaluated are shown in Table 5. The range of values depends on the type of use made of the reclaimed water. Italy, Spain, Greece and Cyprus include their own limit values for some parameters such as heavy metals and agronomic parameters (e.g. SAR, nutrients).

As regards Cyprus, the following limit values and parameters refer to the quality requirements for treated water used for irrigation produced from small – scale wastewater treatment plants ≤ 2.000 p.e. that also includes further monitoring obligations when the tertiary effluent is discharged to underground waters (during the winter period) taking into consideration the standards specified to Groundwater Directive 2006/118/EC. Moreover, further monitoring obligations are set up in the Waste Discharge Permits regarding the treated water from wastewater treatment plants ≥ 2.000 p.e..

Table 5 - Maximum limit values according to the intended use for parameters included in the evaluated water reuse standards

Analytical parameters	Cyprus#	France	Greece	Italy	Portugal	Spain
Microbiological parameters						
- *Escherichia coli* (cfu/100ml)		$250-10^5$	5-200	10		$0-10^4$
- Faecal coliforms (cfu/100ml)					$100-10^4$	
- Total coliforms (cfu/100ml)			2			
- Faecal enterococci (log reduction)		2-4				
- *Legionella* sp. (cfu/l)						$0-10^3$
- *Salmonella* sp.				absence		absence
- Sulphate-reducing bacteria (log reduction)		2-4				
- Helminth eggs (Intestinal nematodes) (eggs/l)					1	0.1
- F-specific bacteriophages (log reduction)		2-4				

Analytical parameters	Cyprus #	France	Greece	Italy	Portugal	Spain
Physical-chemical parameters						
- Total suspended solids (TSS) (mg/l)		15	2-35	10	60	5-35
- Turbidity (NTU)			2-no limit			1-15
- Biochemical oxygen demand (BOD_5) (mg/l)			10-25	20		
- Chemical oxygen demand (COD) (mg/l)		60		100		
- pH			6.5-8.5	6.0-9.5	6.5-8.4	
- Electrical conductivity (EC)(dS/m)			3.0	3.0	1.0	3.0
- Total dissolved solids (TDS) (mg/l)			2000		640	
- Sodium adsorption ratio (SAR)			12*	10	8	6
- Chlorides (mg/l)			350	250	70	
- Total nitrogen (mg/l)			30	15		10**
- Total phosphorus (mg/l)			1-2	2		2**
- Bicarbonate (HCO_3)			500			

See Table 5a
* depending on the value of electrical conductivity
** only for aquifer recharge and recreational uses
*** minimum log reduction required.

Table 5 a – Cyprus - Maximum limit values according to the intended use for parameters included in the evaluated water reuse standards

Parameters	BOD_5 mg/l	COD mg/l	SS mg/l	FOG mg/l	E. Coli / 100 ml	pH	Conductivity µS/cm	Cl mg/l	B mg/l	Residual Chlorine mg/l
Frequency	every 1 month	every 1 month	every 1 month	every 1 month	every 1 month	every 1 month	every 1 month	every 1 year	every 1 year	every 1 month
All crops and green areas (a)	10	70	10	5	5	6,5-8,5	2.500	300	1	2
Vegetables eaten cooked (b)	10	70	10	5	50	6,5-8,5	2.500	300	1	2
Products for human consumption and green areas with limited access to the public	25	125	35	5	200	6,5-8,5	2.500	300	1	2
Crops for animal feed	25	125	35	5	200	6,5-8,5	2.500	300	1	2
Industrial plants	25	125	35	5	200	6,5-8,5	2.500	300	1	2

Regarding the frequency of analysis, although there are variations in the parameters and the types of use (Table 6), Spanish and Greek regulations generally set stricter monitoring protocols than do the other countries considered.

However, the several standards existent in the mentioned European countries are usually fit-for-all solutions, where the single variable is the intended use. However, to promote the transition to a circular economy strategy, a holistic approach that combines end-uses and souring environments is needed. Therefore, recently was adopted by the European Commission a proposal for a regulation to establish minimum quality standards for agriculture irrigation that promotes the adoption of fit-for-of human health and environment. This approaches allows the selection of the adequate treatment level and the best technological solution,as it is ab le to provide a higher volume of treated waste water at lower cost than the other options. For agricultural irrigation, an EU Regulation with a "fit-for-purpose" approach and risk management would entail the most environmental, economic and social benefits as compared to other options.
This regulation will propose minimum requirements for the reuse of treated waste water from urban waste water treatment plants, covering microbiological elements (for example, levels of E. coli bacteria) and monitoring requirements for routine and validation monitoring, to ensure that reclaimed water produced in accordance with the new rules will be safe for irrigation. It will also include a risk management framework basis wherebyany additional hazards must be addressed for water reuse to be safe and finally, is expected to increase transparency, since the public will have access to information online about water reuse practice in their Member States

Table 6 - Frequency of analysis according to the parameter and intended use of the evaluated water reuse standards

Analytical parameters	Cyprus #	France	Greece	Italy	Portugal	Spain
Escherichia coli		1/week 1/two weeks 1/month	4/week 2/week 1/week	x		3/week 2/week 1/week
Faecal coliforms					x	
Total coliforms			7/week 3/week			
Faecal enterococci		1/week 1/two weeks 1/month				
***Legionella* sp.**						3/week 1/month
***Salmonella* sp.**				x		1/two weeks 1/month
Sulphate-reducing bacteria		1/week 1/two weeks 1/month				
Helminth eggs **(Intestinal nematodes)**					x	1/week 1/two weeks

Analytical parameters	Cyprus	France	Greece	Italy	Portugal	Spain
F-specific bacteriophages		1/week 1/two weeks 1/month				
Total suspended solids (TSS)		1/week 1/two weeks 1/month	24/year 12/year 4/year	x	x	1/day 1/week
Turbidity			4/week 2/week			1/day 1/week 2/week
Biochemical oxygen demand (BOD_5)			24/year 12/year 4/year	x		
Chemical oxygen demand(COD)		1/week 1/two weeks 1/month		x		
Heavy metals and metalloids			12/year 4/year 2/year 1/year	x	x	1/two weeks 1/month
pH			2/year 1/year	x	x	
Electrical conductivity (EC)			2/year 1/year	x	x	1/two weeks 1/month
Total dissolved solids (TDS)			2/year 1/year		x	
Sodium adsorption ratio (SAR)			2/year 1/year	x	x	1/two weeks 1/month
Chlorides			2/year 1/year	x	x	
Total nitrogen and Total phosphorus			24/year 12/year 4/year	x	x	1/week 1/month

See Table 5a
X: frequency established by those responsible for the reclaimed water process, in compliance with the authorities

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Current water reuse practice

Italy	60% agriculture; 25% energy and industrial sectors; 15% civil sector. Reuse not allowed for: potable use; direct contact with raw food; watering out of green areas open to the public. Legislation does not regulate the reuse of wastewater within the same factory or industrial consortium that produced it. No distinction between types of reuse, providing the same chemical and microbiological restrictive limits.
Portugal	Irrigation of golf courses, agriculture and ecosystem support. New legislation for the use of treated wastewaters under development. Water reuse projects need permit delivered by the Portuguese Environment Agency. The quality standards are selected according the ISO standards and a multi-barrier approach is applied to reduce risks for human health and surrounding environment.
Malta	Irrigation within the agriculture sector. A distribution network has been set up specifically to distribute polished water to fields throughout the island. A number of distribution points are also available to farmers to collect water via bowser. A pre-paid card system is in place in order to regulate the distribution of the water. Farmers benefit from a more secure water supply, including during times of drought when other irrigation sources may not be available.
Cyprus	51,4% irrigation; 16,1% in aquifers for irrigation; 27,6% into dry bed for infiltration; 1,5% in dam for irrigation. Water reused in agriculture and only during the winter period when the demand for irrigation is limited a minor quantity is discharged into the sea, suitable for the majority of the crops such as animal feed, olive trees, citrus trees, green areas. Not allowed for leafy vegetables, strawberries and bulbs and condyles eaten raw, potato and beetroots. Use of sludge from WWTPs for agriculture purposes is regulated by Law.
United Kingdom	Irrigation of golf courses, parks and gardens, car washing, cooling, fish farming and industry. More than 40 % of the total water demand is for domestic purposes. Of this amount, 30 % is used for toilet flushing. UK has only an emerging direct or planned reuse sector and a non-reuse specific regulatory environment. Langford WWTP in the South East of England is one of only a small number of reuse schemes.
Turkey	Reuse of treated wastewater regulated by Communique of WWTPs Technical Methods. Technology requirements for recovery of wastewater are related to the intended use of the water to be recovered. If urban wastewater is to be used in agricultural or green area watering, disinfection is required. In case of direct or indirect recovery, further treatment alternatives such as membrane technology, activated carbon and advanced oxidation are required.
The Netherlands	To stimulate the reuse of water tax are raised on the use of fresh ground water while the use of reused treated wastewater has a discount. Despite these measures two major industries currently use only fresh ground water: agriculture and thermal energy storage in cities, since there is no shortage of fresh ground water to trigger these industries to also reuse treated ground water. Examples of water reuse: horticulture area Nieuw-Prinsenland, Greenhouse water recycling, in the galvanic industry.

Current technologies/BATs

When treated wastewater is to be reused, there is a need for additional treatment in order to minimise health and environmental risks and ensure its quality and fitness for the foreseen use. The additional treatment is called reclamation treatment and is carried out in water reclamation plants (WRP) as an additional process in the WWTP. The main objective of reclamation treatment is to remove pathogens and chemical contaminants.

Reclamation technologies can be classified as intensive (conventional) and extensive technologies (non-conventional) (Table 7):

- Intensive technologies are characterised by the need for large quantities of energy and minimum space. They are accelerated artificial processes that can be rapidly modified if needed. In addition, they need highly specialised operation and maintenance personnel;
- Extensive technologies, on the contrary, require a large amount of land because they use environmental matrices and rely on natural processes for water treatment, so the processes occur at almost natural rates and the energy requirement is very low. These technologies also require low, but very important, levels of operation and maintenance.

Each reclamation technology has its own characteristics and it is usually necessary to use a combination of two or more technologies to achieve the required water quality levels. The selection of the reclamation technology must take into account several premises such as the quality and the quantity of the water to be reclaimed, the final quality required for the specific use, the economic cost, and the environmental impact.

Table 7 - Intensive and extensive reclamation technologies

Intensive technologies	Extensive technologies
Physical-chemical systems (coagulation-flocculation, sand filters)	Waste stabilisation ponds (maturation ponds, stabilisation reservoirs,…)
Membrane technologies (ultrafiltration, reverse osmosis, membrane bioreactor, …)	Constructed wetlands (vertical-flow, horizontal-flow,..)
Rotating biological contactors	Infiltration-percolation systems
Disinfection technologies (ultraviolet radiation, chlorine dioxide, ozone, peracetic acid, …)	

The concept of Best Available Technique (BAT), defined in the Industrial Emissions Directive (IED), can be applied to reclamation technologies. The term BAT implies the selection of the most adequate technique that exists in the market for a specific aim, which is technically and economically viable and has the least environmental impact. The Best Available Techniques Reference Documents (BREFs) have a strong focus on water management in the relevant sectors, and also cover industrial water recycling (e.g. for the chemical sector).

It is essential to have broad knowledge of the efficiency of the different reclamation technologies and their combinations. Regarding the efficiency and reliability of reclamation technologies, further research is needed on:

- the efficiency and reliability of WWTP (secondary treatment), in order to allow reclamation technologies to be more efficient in treating secondary effluents;

- extensive technologies in countries where these technologies are most likely to be appropriate (e.g. Mediterranean countries);
- the generation of removal capacities and byproducts by disinfection technologies;
- industrial-scale research with real operational conditions of WWTPs and WRPs (most of the research on reclamation technologies to date has been made on laboratory and pilot scales).

Once the water has been reclaimed, it is generally necessary to distribute it to the point of use. For such transport, reclaimed water has to be stored and distributed using storage and distribution systems which may microbiologically and chemically impact the quality of the water. This is why Water Reuse Safety Plans must cover the whole system, from the WRP to the point of use.

A water reuse scheme is likely to have many possible design options: type and degree of treatment, number and location of pumping stations, number, size and location of storage tanks, and layout and size of distribution pipe networks. These elements can be combined into a very large number of design options, even for apparently small systems. The planning of water reuse schemes is therefore highly complex, and a decision support system (DSS) is required that will help in the planning process.

The bottleneck for high-end water recycling systems, which usually involve membrane technologies and consume substantial amount of energy, has been noted. In the near future, the main challenge that may face water reuse is likely to be the development of novel processes that consume less energy and/or enhance energy recovery.

However, the efforts on a water reuse project should not only focus on the best available technology, which could lead to the promotion of fit-for-all solutions that may not be economically feasible. Hence, an important new concept is the fit-for-purpose approach which entails the production of reclaimed water quality that meets the needs of the intended end-users without compromising the human health and the surrounding environment. The use of a risk management framework is crucial to help the definition the most suitable technical solution for each water reuse project. The combined used of suitable technological solutions with additional risk minimization measures will allow the development of a feasible and reliable water reuse project, to produce safe water at a lower price meeting the circular economy principles.

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Current technologies/BATs

Italy	Refining or tertiary treatment indicates a further stage of purification treatment to be carried out after primary treatment and secondary treatment in a purification plant, with the aim of improve the characteristics of the effluent with the reuse objectives described above. The refinement techniques that can be used are quite well established and mainly directed to the removal of the SS and the abatement of the BOD_5. The main ones use: microfilters; slow sand filters; quick sand filters; gravel filters on secondary sedimentation tanks; activated carbon contactors.
Portugal	Majority of the current projects involves the disinfection stage to produce water with quality for the intended use. The most common disinfection methods in presence are UV radiation and prior to this a filtration step as sand filtration or microfiltration. Whenever justified, a post-chlorination step is applied to prevent recontamination and/or regrowth in the distribution systems. For projects under development new technologies as ultrafiltration membranes are start to being test. For some industrial effluents some small projects to produce water for internal uses involve reverse osmosis.
Malta	New water is produced from the polishing of treated waste water which has till now been treated to bathing quality and disposed of in the sea. It is a three stage process comprising of ultrafiltration, reverse osmosis, advanced oxidation and UV treatment. Lime is also being added prior to being supplied in order to increase the level of minerals.
Cyprus	The WWTPs are equipped with tertiary treatment, consisting of sand filtration and chlorination in order to achieve higher quality characteristics to reuse the treated wastewater in the agriculture. Some of the recent plants are equipped with advanced technologies such as membranes bioreactors and UV Disinfection. Conventional treatment technologies are used for the sludge treatment. Sludge is then used as a fertilizer in agriculture.
United Kingdom	Initial treatment is primary settlement and secondary biological treatment by trickling filters and activated sludge. Advanced treatment process at Langford WWTP: chemical-phosphorus removal; biological denitrification; biological nitrification; UV disinfection. It does apply reverse osmosis treatment.
Turkey	Effluents from treatment plants are used for irrigation at parks and gardens and utilized in stabilization ponds for agricultural purposes. An example of MBR Application is the WWTP of Konacık Municipality (Muğla city).
The Netherlands	Cleaning of urban and industrial wastewaters in a communal WWTP consists of the following steps. 1st step: Removal of raw materials such as toiletpaper, wood, etc; Removal of sand; First settlement of organic matter. 2nd step: Unaerobic treatment with active sludge; Aerobic treatment with dissolved air. 3rd step: the removal of phosphate and nitrogen. 4th step is not practiced in general yet. In this step the treatments of waste water could be practiced by using: sandfilters, ozone, ultrafiltration. It is not allowed to use the sludge of the WWTP on agriculture land without treatment.

Expected water reuse practice in Member States/barriers against water reuse

Despite the water reuse applications already developed in many countries, in Europe overall a small proportion of reclaimed water is currently reused mainly due to a general a lack of confidence in the practice. Indeed, a number of barriers still prevent the widespread implementation of water reuse throughout Europe and on a global scale. These barriers will have to be overcome if water reuse strategies are to be adopted on a larger and more effective scale than at present, developing the huge ecoinnovation potential in terms of technologies and services related to water recycling in industry, agriculture and urban sectors. The main barriers identified are:

- inconsistent or inadequate water reuse regulations/guidelines, which lead to delays and misjudgement and thus a lack of confidence in the health and environmental safety of water reuse practices;
- some trade barriersfor agricultural goods irrigated with reclaimed water in European Union, since once on the common market, the level of safety in the producing Member States may not be considered as sufficient by the importing countries;
- inconsistent and unreliable methods for identifying and optimizing appropriate wastewater treatment technologies for reuse applications, which are able to balance the competing demands of sustainable processes;
- low price of freshwater compared to reused water in particular and high cost of treatment for production of reused water to a lesser extent (economical barrier);
- distance between wastewater treatment plants and water use sites;
- difficulties in specifying and selecting effective monitoring techniques and technologies for the whole system;
- significant challenges in reliably assessing the environmental and public health risk/benefit of water reuse across a range of geographical scales;
- inadequate or complex permiting process that needs to ensure safety for public and environment, and therefore along the all chain, from the producing to the the distribuition and application of reclaimed water;
- poorly developed business models for water reuse schemes, and markets for reclaimed water;
- low levels of public and government enthusiasm for water reuse;
- limited institutional capacity to formulate and institutionalize recycling and reuse measures;
- lack of financial incentives for reuse schemes.

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Expected water reuse practice

Italy	Use of wastewater for irrigation or industrial purposes occurred almost exclusively in situations of "water emergency" as lack of water availability and high demand for water in limited portions of the territory destined to intensive agriculture. Only in recent years it has begun to plan the reuse of wastewater with a broader vision, taking into account the indirect advantages of this practice as the environmental benefit of "non-discharge" and the possibility of not using qualitatively better waters, especially groundwater.
Portugal	Portugal is developing a new regulation for the use of reclaimed water, a new governance strategy to promote water reuse and also a guideline to clarify

	administrative process and technical issues as the risk assessment methodologies, the choice of adequate treatment levels or the monitoring plans for reclaimed waters and environment. New governance strategy is expected to promote an holistic approach from the receptor to the reused water and consequently increase the use of treated wastewaters.
Malta	Reclaimed water to be used for all crops destined for human/livestock consumption, for non-food crops and for public green areas. This water will also be used in industry as long as no direct contact is made with food, pharmaceutical or cosmetic products, such as in car wash stations, cooling towers, boilers and possibly laundries.
Cyprus	Cyprus applies an aquifer recharge scheme, where reused water recharges the aquifer through specially constructed shallow ponds. The water, after natural purification, is used for irrigation. Pumping is carried out in a controlled way so that retention time in the aquifer is maximized.
United Kingdom	English regulatory bodies support and encourage water companies to consider indirect effluent reuse as an option for increasing public water supply where a deficit in water supplies is forecast. There are a number of effluent reuse schemes proposed in the current set of draft water resources management plans.
The Netherlands	The developments on reuse of wastewater focuses on use of different constituents of urban wastewater such as: paper from cellulose, phosphate for use in fertilizer, protein for use in (pet)food (is not permitted at this time), making energy from sludges, use of rough materials in new products.

Barriers to the implementation of the expected water reuse practice

Italy	Main barriers are: infrastructural; economic; agronomic; sanitary (bacteria, viruses and parasites).
Portugal	Negative perception on the “use of wastewater”, which needs to be countered by robust educational campaigns and positive results from real projects. Distance between the treatment plants and the water use site. Economical barriers linked with the low price of freshwater compared with the treated wastewater.
Malta	Public perceptions that may drive fear of the dangers of consuming food irrigated with reclaimed water. Overall economic feasibility for the Reclamation Plant Operator to recover costs and subsequently work at a profit.
Cyprus	One of the main barriers initially was the price. This was the reason that reflected the imposition of substantial subsidies to reclaimed water supplies to encourage wider uptake. The decision about the position of a wastewater treatment plant among other parameters takes into consideration whether there is agriculture in the area in order to minimise the length of the networks and the energy consumption needed for pumping the reused water.
United Kingdom	Main barriers are: human health, environment, perception, regulation, ownership, carbon and scheme costs.
The Netherlands	Legislation on food safety currently does not allow reuse of products from urban wastewater recovery. European and local legislation on the reuse of treated urban wastewater labels treated industrial and urban waste water as waste and not as a raw material. Therefore, reuse is only possible after an ‘End Of Waste’ procedure. Medicine-residues and hormones in the treated waste water. Economical feasible techniques in order to clean the water to a safe standard.

Current quality requirements for irrigation vs JRC (European Requirements)

As already known, of the Member States where water reuse is being practiced, standards have been developed by Cyprus, France, Greece, Italy, Portugal, and Spain. In all countries apart from Portugal these standards are legally binding. All the standards cover water reuse practices for agricultural irrigation of crops and orchards and all but Cyprus's cover water reuse for irrigation of pastures.
Aquifer recharge (by surface spreading or direct injection) is only considered as a permitted use in Cyprus, Greece and Spain.
Many of the standards developed at Member State level have been informed by the 2006 WHO Water Reuse Guidelines, the ISO guidelines on safe use of wastewater for irrigation use and regulatory approaches in other countries (e.g. Australia, Israel, USA) but also by specific national considerations. In general, there is little harmony among the water reuse standards proposed by individual EU Member States. Thus, there is concern that this lack of harmonized requirements can create some trade barriers for agricultural goods irrigated with reclaimed water and a perception that there are different levels of safety for similar irrigation practices (JRC, 2014).

To overcome this issue and to foster water reuse as a core element of the EU action plan for the Circular Economy, the Joint Research Centre (JRC) was asked by the European Commission to develop a technical proposal for minimum quality requirements for water reuse in agricultural irrigation and groundwater recharge. The findings of the JRC have been published in an initial draft document in October 2016 and after several iterations and advice provided by the independent Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and the European Food Safety Authority (EFSA), the findings and proposed requirements were revised in June 2017 (JRC, 2017). The core water quality requirements for water reuse in agricultural irrigation proposed in the JRC report are summarized in Tables A and B.

Table A - Minimum quality requirements for reclaimed water in agricultural irrigation (JRC, 2017)

Reclaimed water quality	Indicative technology target	Quality criteria				
		E. coli (cfu/100 mL)	BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Additional criteria
Class A	Secondary treatment, filtration, and disinfection (advanced water treatments)	≤10 or below detection limit	≤10	≤10	≤5	*Legionella* spp.: <1,000 cfu/l when there is risk of aerosolization in greenhouses. Intestinal nematodes (helminth eggs): ≤1 egg/l when irrigation of pastures or fodder for livestock.
Class B	Secondary treatment, and disinfection	≤100	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	
Class C	Secondary treatment, and disinfection	≤1,000	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	
Class D	Secondary treatment, and disinfection	≤10,000	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	

Table B - Classes of reclaimed water quality and associated agricultural uses (JRC, 2017)

Crop category	Reclaimed water quality class	Irrigation method
Food crops consumed raw where the edible portion is in direct contact with reclaimed water **Root crops consumed raw**	Class A	All irrigation methods allowed
Food crops consumed raw where the edible portion is produced above ground **Food crops consumed raw with inedible skin (skin removed before consumption)**	Class A Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Processed food crops	Class A Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Non-food crops including also crops to feed milk- or meat-producing animals	Class A Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Industrial, energy, and seeded crops	Class A Class B Class C Class D	All irrigation methods allowed

In table C is represented a comparison of water reuse standards of individual Member States (JRC, 2014) with the standards proposed in the JRC report (2017) and the requirements for irrigation water quality to address microbial risk for fresh produce proposed by the EU Commission (2017).

Table C – Comparison of maximum limit values adopted from JRC (2014), EU Commission (2017) and JRC (2017)

Parameters	**Cyprus #**	**France**	**Greece**	**Italy**	**Portugal**	**Spain**	**EU Com. (2017)***	**JRC Report (2017)**
E. coli (cfu/100 mL) *E. coli* (logs)	$5\text{-}10^3$ -	$250\text{-}10^5$ -	5 – 200 -	10 -	- -	$0 - 10^4$ -	$100 - 10^4$ -	$10 - 10^4$ >5
Fecal coliforms (cfu/100 mL)	-	-	-	-	$100 - 10^4$	-	-	-
Enterococci (logs)	-	≥2 - ≥4	-	-	-	-	-	-
Anaerobic sulf. red. spores (logs)	-	≥2 - ≥4	-	-	-	-	-	-
Clostridium perf. spores (logs)	-	-	-	-	-	-	-	>5
Bacteriophages (logs)	-	≥2 - ≥4	-	-	-	-	-	-
F-spec. coliphages (logs)	-	-	-	-	-	-	-	>6
TSS (mg/L)	10 – 30	15	2 – 35	10	60	5 – 35	-	10 – 35
Turbidity (NTU)	-	-	2 – no limit	-	-	1 – 15	-	5
BOD_5 (mg/L)	10 – 70	-	10 – 25	20	-	-	-	10 – 25
COD (mg/L)	70	60	-	100	-	-	-	-
Total nitrogen (mg/L)	15	-	30	15	-	10	-	-

Note: *'*Guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene' (EU Commission, 2017)*

As regards Cyprus, this table refers to the old ministerial decree (No. 269/2005) that has been replaced by the Ministerial Decree of small – scale wastewater treatment plants ≤ 2000 p.e (No. 379/2015).

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Current quality requirements

Italy	Italian standards D.M. 185/2003 include maximum limit values for physical-chemical parameters that have to be met for all the intended uses of reclaimed water. Some parameters have limit values similar to those designated for drinking water, even if the reclaimed water is used for uses such as irrigation of green areas. Regarding industrial uses, limit values should, as a minimum, comply with the limit values set for water discharges to surface water (Legislative Decree 152/2006).
Portugal	For irrigation purposes Portugal is already using the quality requirements proposed in the ISO 16075. To each irrigation project, according the end-uses, a class A, B, C or D is proposed combined with several minimization measures, i.e., multi-barriers. The barriers are chosen according the principle of equivalent barrier as described on the ISO 16075, EPA and WHO standards.
Malta	Malta produces Class A reclaimed water which can be used for all food crops, including root crops consumed raw and food crops where the edible past is in direct contact with reclaimed water. All irrigation methods are permissible.
Cyprus	The quality requirements for treated water used for irrigation usually depends on the type of discharge, the quality of the relevant water body, the corps irrigated, the sensitivity of the area and the size of the WWTPs. Ministerial Decree of small scale WWTPs ≤ 2.000 p.e (No. 379/2015).
United Kingdom	No effluent reuse specific regulations exist in the UK. The most important pieces of legislation which directly affect effluent reuse are the Urban Wastewater Treatment Directive, the Water Framework Directive and the DWI regulations for drinking water. There are currently no formal UK guidelines on the quality of water that can be used in agricultural irrigation.
Turkey	Communique of WWTPs Technical Methods defines the Criteria for treated wastewater usage for irrigation and categorizes treated wastewater in Class A and Class B. According to the category, irrigation of certain types of plants and areas can be permitted. The Communique defines chemical quality of irrigation water, also providing information on the sensitivity of the plants that will be irrigated with treated wastewater.
The Netherlands	In the Netherlands there are no standard requirements for the reuse of treated waste water. The reuse of treated waste water is not allowed by law.

Risk assessment (key issues for environment)

One of the major concerns about water reuse is its safety for both human and environmental health. Direct or indirect contact with reclaimed water may have health implications on individuals, regardless of whether they are the intended users of the reclaimed water or not, regarding the whole chain from the treatment facility to the consumers (in case of agriculture irrigation) or public. Such health implications can be moderate in some cases and serious in others, and continue for a short, moderate, or long time. Also the environment needs to be protected, namely since reclaimed water can contain pollutants of emergent concerns or other contaminants that may present a risk for other envienmental matrix, e.g., salinization of soils.

Than, when reusing water, it is essential to protect both human and environmental health. A risk management approach is the best way to achieve this. Such an approach has been adopted in the water industry in the latest editions of the Australian drinking water guidelines and of the World Health Organization's Guidelines for drinking-water quality (WHO, 2004), which embodies this approach in its risk management plans, named Water Safety Plan (WSP).

The international guidelines on water reuse from WHO and Australia (WHO, 2006; NRMMC-EPHC-AHMC, 2006) recommend the development of a risk management framework similar to the WSP for water reuse systems - the Water Reuse Safety Plans (WRSPs), which are specific when there is a clear evidence of a pathway, e.g., direct contact, but less effective when there no data for other kind of scenarios, like the majority of non.potable uses. To deal with those, recently was published the standard ISO 20426:2018, Guidelines for health risk assessment and management for non-potable water reuse.

A risk management framework is a systematic tool that allows to ensure the safety and acceptability of water reuse practices. This tool also need to be sufficiently flexible to be applied to all types of water reuse systems, irrespective of size and complexity and incorporates several interrelated elements, each of which supports the effectiveness of the others. Since the majority of difficulties associated with water reuse projects derives from a combination of factors, these ones need to be addressed together to guarantee a safe and sustainable supply of reclaimed water.

This type of framework typically includes four requirements:

1. Responsible use of reclaimed water: Engagement of authorities with expertise in water supply, wastewater management and protection of public health;
2. Regulatory and formal requirements: Identification of all relevant regulations, guidelines, and local requirements;
3. Partnerships and engagement of stakeholders: Identification of all authorities with responsibilities and all stakeholders influencing water reuse activities;
4. Reclaimed water policy: Development of a reclaimed water policy, permits and specific contracts with end users.

The risk management framework is used to develop a management or safety plan that describes how the water reclamation system should be operated, monitored and managed. To develop of a risk management framework should be gathered a multidisciplinary team of individuals with adequate experience and expertise in protecting public and environmental health that understands the components of the water reuse system and is well placed to assess the associated risks.

A risk management approach involves identifying and managing risks in a proactive way, rather than simply reacting when problems arise.

In applying this approach to water reclamation, a crucial step is to perform a risk assessment where the first step is to look systematically at all the hazards that the reclaimed water could potentially pose to human or environmental health, establish the several contamination pathwys and all the possible scenarios.

Once the hazards and pathways are identified, the risk of each hazard is assessed by estimating the likelihood and the consequences of its occurrence. The next step is to identify measures to control

or minimize the risk that can be applied directly to the source of hazard, to the pathway or to the risk receptor.
To characterize the risk level quantitative, semi-quantitive and qualitative approaches may be applied, depending on the availability of data related with the hazards, pathways and receptors.
The approach proposed by WHO, namely the Quantitative Microbiological Risk Assessment (QMRA) is very helpful when potable uses and direct intakes may be present. However less attention has being paid for non-potable purposes and for which the dose-response effects are not well known or not determined. For instance, usually drip-irrigation is used on orchards production, where the water does not contact with the fruits and some of these are not also consumed with peel. So, the microbiological pathway from water to the fruit is not easily assessed. To this situations only semi-quantitive or qualitative approaches are vailable.
The establishment of monitoring programmes to ensure that the preventive measures operate effectively are needed during the lifetime of the project to ensure that the risk is maintained as low as reasonably practicable. The monitoring programs can be distinguished in three categories: validation, performed at one time to ensure that project meets the design requirements, operational monitoring to address the complexity of operational systems and its infrastructural capabilities and a verification monitoring, to validate the water quality with the legal requiments.
From the risk management framework should derive a risk management plant to that allows to guarantee that the management system consistently provides reclaimed water of a quality that is fit for the intended use, with a risk as low as reasonably practicable, for human health and environment.
It must be pointed out that the implementation of the risk management framework will lead to the most suitable solution according intended uses and surrounding environment, and therefore to the most economical feasible project and also promote better target resources in the longer term.

The risk management framework is not mentioned in the Member States regulations as a tool to be applied by MS. But some elements of the RMF are sometimes included. Supplementary physic-chemical parameters appear in some MS regulations, mainly agronomic parameters, while the minimum quality requirements proposed are recommending the application of a risk assessment according to local conditions to derived additional requirements for monitoring.

	JRC	Cyprus	France	Greece	Italy	Portugal	Spain
ALL CATEGORIES							
Application of elements from a risk management framework	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
Elements applied	All elements	Multiple barrier	Multiple barrier, validation monitoring	Multiple barrier		Multiple barrier	Multiple barrier
Additional physico-chemical parameters and limit values	Depending on risk assessment results	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Parameters		Heavy metals, nutrients		Heavy metals, nutrients, organic substances	Heavy metals, nutrients, organic substances	Heavy metals, nutrients, organic substances	Heavy metals, nutrients

Additional requirements included in MS standards and in the proposed minimum requirements for water reuse in agricultural irrigation.

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Risk assessment (examples and applied methodologies)

Italy	The risk management framework is not mentioned in Italian regulation as a tool to be applied by the Country, but additional physico-chemical parameters are considered such as heavy metals, nutrients and organic substances.
Portugal	Portugal is preparing a new regulation for water reuse for several purposes besides the agriculture irrigation in which a risk management approach will be embed. However, the current permitting process already applies part of this concept and some research work is being conducted under the semi-quantitative approaches for non-potable uses.
Malta	The Water Services Corporation, being the reclamation plant operator for Malta, shall draw-up a Water Reuse Risk Management Plan based on key risk management tasks. The Water Reuse Safety Plans must cover the whole system, from the Water Reclamation Plant to the point of use.
Cyprus	The Technical Committee assess the potential environmental effects of planned developmental activities related to the design, construction and operation of sewerage systems and urban WWTPs as well as the management of the treated wastewater to identify and evaluate the positive and negative impacts to the environment and to the public health.
United Kingdom	Environmental impact assessment and options appraisal of any proposed effluent reuse scheme is important to protect the environment and other interests from any negative impacts of changes to the flow regime and water quality that effluent reuse may cause. Looking at the costs and benefits to provide recommendations to minimise negative impacts. An appropriate risk-based approach to water quality monitoring and wastewater catchment characterisation will be required to inform decisions on potable water quality testing.
Turkey	Risk assessment framework is not mentioned in Turkish regulation as a tool to be applied by the country.
The Netherlands	In the Netherlands there are no standard requirements for risk assessment for the reuse of treated waste water. The reuse of treated waste water is commonly not allowed.

Monitoring

The development and implementation of an appropriate monitoring strategy is a crucial step for the health and environmental safety of any water reuse project. Monitoring can be undertaken for a range of purposes, and for each specific objective, different parameters should be selected. The main targets of monitoring programs are:

1. Protection of human health;
2. Protection of environment against of adverse effects (natural water sources and soil);
3. Prevention on adverse effects on crops (food and non-food crops);
4. Prevention of integrity of distribution systems (e.g. prevention of clogging of irrigation system).

For a water reuse project, according the intended use at least two types of monitoring programs should be implemented, namely, operational monitoring and compliance or verification monitoring. When more restricted uses are present, i.e., uses that requires a water with a high level of quality should also be performed a validation monitoring.

To assure the appropriate performance of the water reuse system to deliver the requested level of reclaimed water quality an operational monitoring protocol should be defined to establish the operational procedures for all activities and process applied within the whole water reuse system to ensure that all preventive measures implemented to control hazards are functioning effectively. An operational monitoring program usually includes parameters that can be readily measured and provide an immediate indication of performance of the preventive measures to enable a rapid response (e.g. disinfectant residuals and other disinfection related parameters or on-line parameters, such as turbidity). Operational parameters should be measured in specific critical points and associated with correspondent target limits to define effectiveness and detect variations in performance.

The compliance or verification monitoring are specifically linked with the need of protection of human health and environment. These programs are usually defined by national authorities and ideally included in the permits applied to the water reuse projects. The several parameters should be defined to ensure that the projects runs in an adequate level of protection and therefore, they should be chosen to control the risks from direct and indirect contamination pathways for humans and environment, namely, water (surface and groundwater), soil and/or crops. Typical parameters in validation monitoring programs are microbiological parameters (e.g. E. coli, helminth eggs or legionella), organic matter (BOD_5 and COD), Solids (TSS) and nutrients (N and P). Depending on the need of environment protection and the results of the risk assessment, other parameters can also be included in programs such as salinity, SAR or heavy metals for soils and crop protection or, according the origin of the raw wastewaters, some pollutants of emergent concern.

A validation monitoring program is previewed in the new European Regulation proposal for projects that requires a high level of quality. This program aims to guarantee that the treatment performance meets all its design requirements. These kind of programs propose target limits expressed in performance requirements for specific microorganisms indicators (bacteria, virus and protozoa).

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Monitoring

Italy	The Italian standards do not consider a frequency of analysis. This frequency should be established by those responsible for the facility, in accordance with the authorities and always taking into account the variability of water characteristics. A monitoring program could provide for a qualitative control of the new waters before distribution and in irrigated parcels, with analysis of irrigated soil and fruit.
Portugal	Each permit is delivered by the water authority and defines a compliance or verification monitoring program that is specific for each project according the requirements for end-uses and the characteristics of the surrounding water bodies, namely status and uses. If needed the agriculture authorities may define the need of crops and/or soil monitoring.
Malta	Reclaimed water is currently being analysed for E.coli, BOD5, TSS, Turbidity and Legionella spp. twice a week. Moreover, the water being produced after each process, i.e. ultrafiltration, reverse osmosis and advanced oxidation is also regularly monitored. Further parameters, including a number of organics, emerging pollutants, pesticides and metals are also regularly analysed for polished water.
Cyprus	Monitoring include the sampling and analyses of chemical, physical and microbiological parameters of the treated wastewater such as: BOD5, COD, SS, heavy metals, phosphorous and nitrogen, residual chlorine, priority substances and pathogens. Further monitoring obligations are set up in the permit for the monitoring of the groundwater and soil in the irrigated area, as well as the surface water and the aquifer if its relevant.
United Kingdom	The Langford Risk assessment and mitigation required years of baseline data for the reuse scheme to be successful. Ten years of environmental monitoring preceded the opening of the Scheme. Demonstrating that the Scheme will comply with WFD objective of “no deterioration”.
Turkey	Communique of WWTPs Technical Methods defines the monitoring frequencies depending on the classes from continuous, to daily or weekly basis.
The Netherlands	In the Netherlands are no standard requirements for the monitoring of reuse of treated waste water. The reuse of treated waste water is commonly not allowed.

Benchmarking good practice

The assessment of the current practices in the member states does not allow to promote a benchmarking. Indeed, some countries promoted a fit-for-all solution, i.e., an application of advanced technology to deliver a high class of water quality for a major specific purpose, namely, agriculture irrigation (e.g., Malta and Cyprus) and others promote different solutions according the intended uses, such as Portugal or Turkey.

The fit-for-all of practice may be applicable for similar basins with parallel characteristics and when a single major end-use is present. However, when several end-uses with different quality requirements co-exist, a fit-for-purpose solution presents a better option since allows to put efforts where needed.

Other important aspect is the need of the promotion of a risk assessment and a cost-benefit analysis previous to the project development, to ensure that the treatment system is the one that better adjusts to the requirements and an adequate multibarrier scheme is adopted to keep the risk for human health and environment as low as reasonably practicable. However, no current project seems to be developed under these strategy.

The assessment of water reuse cost and the way that end-users are engage is also an part that needs further study, namely to ensure feasible practices under the principles of the circular economy.

Other critical aspect that needs a deeper analysis is the responsibility for the water quality from the outlet of the treatment system to the point of application. An adequate permitting process may help authorities dealing with this question.

Therefore, besides the existence of good practices already in place in several countries, the simple adoption of it by other countries may not represent the best option. Further research on the patterns of its use seems to be need to promote be a better understanding of how, when and where the good practices are applicable.

This results would present a great advantage for future project development of water reuse, such as projects for agriculture irrigation taking into account the future European regulation. Also, the knowledge of the use of good practices linked with the cost-benefit analysis can promote a real transition to the circular economy.

Water reuse costs

In most countries available data is currently insufficient to generate scenario based cost ranges that would provide reasonable indicative capital or operating costs.

In the following table some examples from all the participant Member States in the current project are summarized. For details see the Annex.

Water Reuse Costs

Italy	The average costs for reuse, as calculated by ISPRA in a Survey of several Italian recycling plants (different plants for different uses: urban, industrial, agriculture) range between 0.0083 and 0.48 €/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 €/m^3. The high cost of recycled water is generally indicated as one of the main barriers to water reuse.
Portugal	Available data is currently insufficient to generate scenario based cost ranges that would provide reasonable indicative capital or operating costs.
Malta	The tariff related to the first block of 2,500m^3 for all consumers of highly polished reclaimed water for agricultural purposes shall be free of charge until such time as when the Minister responsible for the Water Services Corporation so orders that the tariff found in sub-paragraph (i) enters into effect. The tariff bands which shall be applicable on a per holding basis for the highly polished reclaimed water supplied for agricultural purposes.
Cyprus	In Cyprus, from the very beginning, reused water was supplied for irrigation at a price that is 33% to 40% of that paid for conventional freshwater. This was a strong incentive for the users to accept reused water as a new reliable water resource. The cost of the reused water is subsidized by the Government since, the cost of its production is much higher than the conventional sourced water. This is because of the high quality standards required.
United Kingdom	Available data is currently insufficient to generate scenario based cost ranges that would provide reasonable indicative capital or operating costs.
The Netherlands	In The Netherlands the reuse of treated waste water is commonly not allowed.

Conclusions

The crescent water demand is stressing water resources globally. In a climate change scenario. These pressures over water bodies besides being more visible in arid or semi-arid areas, the water scarcity pattern is changing and is being aggravated by the climate change scenario and is starting to appear in other latitudes. Also the season variations can intensify the water consumption when less freshwater is available and affects negatively the water balance.

These critical aspects combined with the water pollution control efforts have made treated a suitable and alternative source of augmenting the existing water supply, especially when compared to expensive alternatives such as desalination.

Should also be noticed that the overall pressure over water bodies has a direct impact on its quantity and quality and the reuse of treated wastewater could be also a beneficial solution to improve water body's quality, such as for example avoiding wastewater treatment plants discharge upstream sensitive areas.

Although the use of reclaimed water is an accepted practice in several countries, the uptake of water reuse solutions remains limited in comparison with their potential. As previously said, one of the main barriers identified is the lack of harmonization in the regulatory framework to manage health and environmental risks related to water reuse. To overcome this issue, European Union is proposing a new regulation for agriculture irrigation but other uses will not be controlled. Other important and critical aspect is the permitting process and the attribution of responsibilities in the several steps and stages of a water reuse project.

The comparison between current practices can help to identify best management and permitting options and also identify problems related with future regulation in an early stage.

The results from 2018 showed that use of reclaimed water is increasing its importance in Europe and therefore a better understand of the practice is needed to avoid direct and indirect risks for human health and environment.

However, from the collection of results on practical cases, site-visits and meeting discussions, is clear that some data are still missing and further research should be developed. A deeper understanding of the existent practical solutions, namely in terms of risk assessment would be useful to clarify the realist risk level currently in place.

Critical aspects identified are linked with the current use of fit-all-approaches where projects are defined by the level of the treatment facility which may jeopardize the current trend for the use of fit-for-purpose approaches in which treatment requirements combined with preventive measures or barriers (i.e., application a multi-barrier concept) are defined to meet the end-users and surrounding environment requirements.

A better understand on the best practice to close the loop of the water use is needed since the usual measures such as reduce the freshwater consumption and direct reuse may affect other aspects of the cycle, such as the increasing of loads in raw wastewaters that may lead to a need of higher energy consumption, higher emissions of CO_2, increase risk of failure of the treatment facilities and to decrease natural values. Therefore, an integrated approach of water use is needed to be addressed to ensure a correct water usage that contributes for the good water status and to ensure the transition to the circular economy. According the current developments of water reuse in Europe, this project and its outcomes could be useful for some of the European Commission current works in this field.

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ANNEX (examples from participant Member States)

Current water reuse practice

Italy

In Italy, at present, the situation of the water reuse is as follows:
- about 60% is reused in agriculture;
- about 25% is reused in the energy and industrial sectors;
- about 15% is reused in the civil sector.

In Italy, the regulations do not allow reuse for:
- potable use;
- direct contact with raw food;
- watering out of green areas open to the public.

Ministerial Decree n. 185 of 12th June 2003, establishes the technical rules for the reuse of domestic, urban and industrial wastewater in the Country, for the purpose of qualitative and quantitative protection of water resources, limiting the withdrawal of surface water and groundwater, reducing the impact of discharges on rivers and promoting water savings through the multiple use of sewage water. According to the Decree, reuse must take place in conditions of safety for the environment, avoiding alterations to ecosystems, soil and crops, as well as health and hygiene risks for the population. In addition, irrigation reuse must be implemented in ways that ensure water saving.

The following uses are considered eligible for reuse:
- irrigation use: for the irrigation of crops destined for the production of food for human and animal consumption and for non-food purposes, as well as for the irrigation of areas destined for green or recreational or sporting activities;
- civil use: for washing roads in urban centers; for the feeding of the systems of heating or cooling; for the feeding of dual supply networks, separated from those of drinking water, with the exclusion of direct use of this water in buildings for civil use, with the exception of drainage systems in the toilets;
- industrial use: such as fire-fighting, process and washing water and for thermal cycles of industrial processes, with the exclusion of uses that involve contact between recovered wastewater and food or pharmaceutical and cosmetic products.

Therefore, reuse is not allowed for potable purposes. Furthermore, the decree does not regulate the reuse of wastewater within the same factory or industrial consortium that produced it.

The reuse of recovered wastewater must be carried out according to the methods set out in art. 10, schematically shown below:
- in the case of irrigation reuse, it must be implemented in ways that ensure water saving, can not exceed the needs of crops and is still subject to compliance with good agricultural practices, or the nitrogen inputs resulting from the reuse of wastewater contributes to the achievement of the maximum allowable loads and to the determination of the equilibrium between the nitrogen needs of the crops and the contribution of nitrogen from the soil and from fertilization;
- in the case of multiple reuse (i.e. uses other than irrigation, civil and industrial) the owner of the distribution of the recovered wastewater must take care of the correct information

of the users on how they are used, on the constraints to be respected and on the risks connected to improper reuse.

The Decree contains the limit values for the wastewater recovered at the outlet of the treatment plant.
Comparing the annex to the D.M. 185/2003 with the D.M. 2nd May 2006, the latter adds some news to paragraphs 1 and 3 regarding the tasks of the Italian Regions for monitoring and for the definition of some emission limit values. In fact the Regions establish, for each homogeneous zone of their territory, the parameters for which it is mandatory to carry out control and monitoring, setting the limits in compliance with the decree. Moreover, for the chemical-physical parameters (i.e. pH, ammonia nitrogen, conductivity, aluminum, iron, manganese, chlorides and sulfates), the Regions can foresee, on the basis of consolidated knowledge acquired for the different uses and reuse to which wastewater is destined, limits different than those provided in the table of the annex, providing they do not exceed the limits for discharge into surface waters of Table 3 of Annex 5 of Part Three of Legislative Decree n. 152/2006, according to the opinion of the Ministry of the Environment and of the protection of the territory.
Compared to the regulations of other Countries, the Italian legislation regarding agricultural or civil reuse does not provide any distinction between the two types of reuse, providing the same chemical and microbiological limits for the two cases. With regard to microbiological parameters, for example, in the regulations of other Countries, there are also significant variations in the accepted limit values passing from the irrigation of non-food crops to the irrigation of food crops.
The Italian standard pays great attention to the microbiological parameter for which the need to protect human health is not evaluated according to the real risk of spreading epidemiological events through the reused wastewater, but defining particularly strict limits and considering a number of high parameters.
Another aspect not covered by the regulations of other Countries is the definition of requirements on the minimum treatments required according to the types of reuse. The particularly restrictive limits provided by Ministerial Decree 185/2003 and confirmed by the Decree of 2nd May 2006, require the need to carry out very refined treatments to achieve the required values. The severity of the limits has been questioned by numerous technicians who believe that such restrictive values limit the effective possibility of reusing treated wastewater.
Others, however, judge positively the approach that foresees to refer to a microbiological quality class of the undifferentiated wastewater for all the uses, since controls are facilitated as there is no need for differentiated controls depending on the destination of the reused water. This should encourage the dissemination of the practice of reuse, as well as ensuring hygienic safety in any case.

In Italy, the reuse of wastewater for industrial, irrigation and civil use is identified for each Region as part of the national strategy of water consumption saving. The Water Protection Plan of each Region contains facts, figures, strategies and future plans on water reuse.

As can be seen from figure 5, the water reuse application is different in several Regions of Italy. In the North and Center of Italy the main water reuse is industrial reuse and agricultural reuse, also in specialized fields, while in the South of Italy mainly consists in agricultural reuse.
In the last years has been a growing interest in “landscape irrigation”, golf courses, etc.

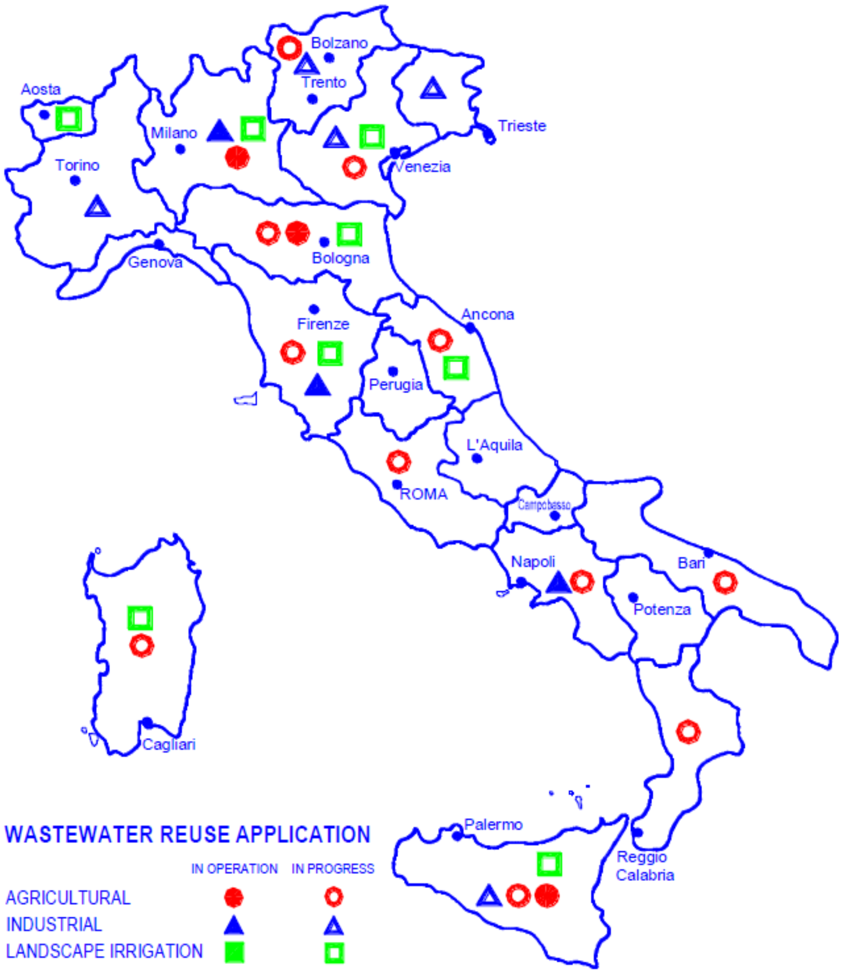


Figure 5 - Water Reuse application in Italy in 2014 (Source: Catania University, prof. CIRELLI)

As can be seen from table 8, Italy uses primarily surface water for irrigation (70%) respect to the groundwater (30%).

In Italy, the irrigable area is totaling up to 3,892,202 ha, while the area actually used for irrigation is summing up to 2,471,379 ha. As an alternative freshwater resource, reclaimed water can be used for agricultural irrigation amounting to 32% as the largest application for water reuse globally (Global Water Intelligence 2015).
The volume of reclaimed water used in Italy, in year 2006, was 233 million m^3/y (TYPSA, 2013).

Table 8 - Areas equipped for Irrigation with groundwater or surface water in Italy (Source: FAO, 2017)

Province	Area equipped for irrigation (ha)		
	total	with groundwater	with surface water
ABRUZZO	59 358	8 077	51 281
BASILICATA	80 640	17 529	63 111
CALABRIA	117 247	64 148	53 099
CAMPANIA	125 305	72 499	52 806
EMILIA-ROMAGNA	565 573	159 981	405 592
FRIULI-VENEZIA GIULIA	91 876	30 886	60 991
LAZIO	150 088	92 602	57 486
LIGURIA	11 391	2 707	8 684
LOMBARDIA	704 517	105 037	599 480
MARCHE	49 559	23 967	25 591
MOLISE	20 881	687	20 194
PIEMONTE	449 047	101 878	347 169
PUGLIA	389 617	308 116	81 501
SARDEGNA	165 707	49 937	115 770
SICILIA	209 035	101 725	107 310
TOSCANA	111 603	41 133	70 469
TRENTINO-ALTO ADIGE	61 774	15 610	46 164
UMBRIA	66 927	17 825	49 103
VALLE D'AOSTA	26 212	506	25 707
VENETO	435 845	70 931	364 914
Italy total	**3 892 202**	**1 285 783**	**2 606 419**

Portugal

In Portugal, the interest in water reuse as an alternative water source is being increase in the last years, mainly due to the occurrence of droughts, including some periods of severe drought. However, the lack of specific regulation and the simple access to groundwater has compromise the practice. Therefore, to counter this fact, a new legislation for the use of treated wastewaters for several purposes is currently under development and is expected to become in force during next year.

Nevertheless, some water reuse projects were developed, namely in the South of Portugal, in Algarve, for the irrigation of golf courses, some agriculture, such as citrus and ecosystem support with treated urban wastewaters. Other example of water reuse involves an agricultural/horticultural symbiosis. Also in Algarve, several small red fruit hydroponic productions are being developed, usually 1 to 2 ha greenhouses. From the irrigation process, near 300 to 400 m^3 per year of drained water is produced (from which 100 to 200 m^3 is produced in the dry season). These waters are rich in nutrients and, therefore, are combined with other water sources (surface water or groundwater) to irrigate other cultures in the surrounding areas, such as citrus fruit trees, pomegranate trees or hedges. With this symbiosis, nearly 15% of the total irrigation needs, in July, are met by the water reuse. The consumption of chemical fertilizers is also reduced (≈10-12% in P and N).

According the Portuguese Law, a water reuse project needs a permit delivered by the water authority, the Portuguese Environment Agency, which previously involve a formal opinion from the public health and agriculture authorities for the irrigation of crops and only from the public health authority for the irrigation of public green areas, such as green parks or recreational and sports fields. The quality standards delivered in each permit are currently selected according the ISO standards and a multi-barrier approach is applied to reduce risks for human health and surrounding environment. Some examples of applied barriers are type of irrigation system, irrigation schedule,

post-disinfection or distance to residential areas. Whenever justified is asked the monitoring of receiving water bodies, groundwater or surface water.
One of the best examples of a water reuse project in Portugal is the Irrigation of a golf course and the maintenance of an ecosystem from a single treatment plant, named Albufeira Poente, with capacity for 140000 p.e. Daily, an average of 14500 m^3 of tertiary effluent are used to irrigate the course and remain flow is used to keep a pond classified as protected landscape under the habitats directive, which is an important nesting area for protect bird species. Other best practice was the preparation of a public green area for a music festival, “Rock in Rio 2018”, in Lisbon. To ensure safety for the public and for the workers, the irrigation of the grass was made a few weeks before the event and only during the night periods to avoid the direct contact between the water and humans. The origin of the treated wastewaters was a urban treatment plant, named Beirolas, with more advance than secondary treatment level, namely UV disinfection.

Malta

Since Malta is one of the EU countries that suffers from water stress all year round, a lot of resources have been invested in the water reclamation technology that have been set up in the three Waste Water Treatment Plants that are currently being operated in the Maltese Islands. At present, only one reclamation plant has been commissioned, with the other two to be commissioned within the next couple of months. Reclaimed water is being used in irrigation within the agriculture sector. A distribution network has been set up specifically to distribute polished water to fields throughout the island. A number of distribution points are also available to farmers to collect water via bowser. A pre-paid card system is in place in order to regulate the distribution of the water. Since there is less over abstraction of the ground water, this would eventually result in an overall improvement of this natural resource. Moreover, farmers would benefit from a more secure water supply, including during times of drought when other irrigation sources may not be available.

Cyprus

In Cyprus, the treated wastewater is an important water resource. It is the Government's policy and is implemented through the obligation for tertiary treatment, the UWWTPs effluent to be reused in agriculture and only during the winter period when the demand for irrigation is limited, a minor quantity of the tertiary effluent is discharged to the sea.

Regarding the treated wastewater produced from the UWWTPs serving agglomerations with ≥ 2.000 p.e., according to 2016 data (figure 6), **51,4%** of the treated wastewater is reused direct for irrigation, **16,1**% in Ezousa and Akrotiri aquifers for irrigation, **27,6**% into the dry bed of Pediaios and Serrachis River for infiltration and **1,5%** in Polemidia Dam (for irrigation). Only a small quantity during the winter period when the demand of irrigation is limited is discharged into the sea and Athalassa reservoir.

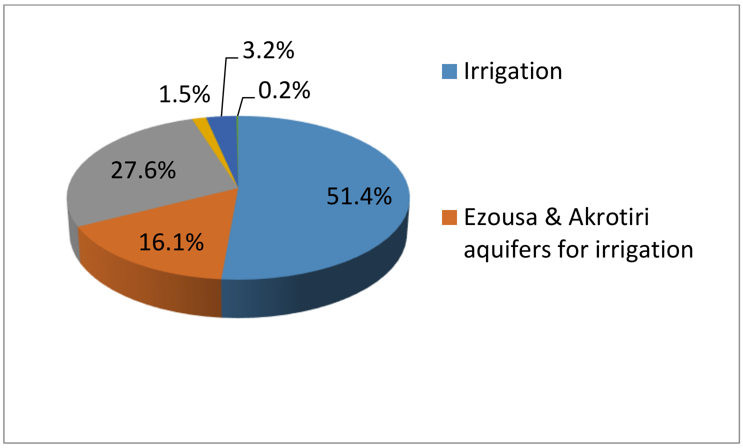


Figure 6 - Water Reclaimed water reuse 2016

The UWWTPs effluent is mainly reused for irrigation and it is suitable for the majority of the crops such as animal feed, olive trees, citrus trees, green areas e.t.c.. It is not allowed for leafy vegetables, strawberries and bulbs and condyles eaten raw, potato and beetroots.

The management of the treated wastewater is implemented through a permitting and inspection system under the Water Pollution Control Law as well as Regulations and Ministerial Decrees. Waste Discharge Permits for the operation of the UWWTPs and the management of the effluent are issued by the Minister of Agriculture, Rural Development and Environment.

Each permit includes specific conditions regarding measures that must be taken by operator. Most commonly, measures refer to the following:

- Discharge method, quantity, areas, crops irrigated etc
- Sludge Management
- Monitoring of effluent quality and quantity and record keeping
- Compliance with relevant quality requirements
- Submitting annual reports
- Record keeping

The authority that is responsible for issuing Waste Discharge Permits is the Department of Environment of the Ministry of Agriculture, Rural Development and Environment. The Department of Environment, through inspections and annual reports ensures that the permit conditions are met, in order to achieve protection of water and soil.

The Water Pollution Control Law as well as related Regulations and Ministerial Decrees are published (in Greek language) on the website of the Department of Environment http://www.moa.gov.cy/environment.

Sludge

In Cyprus, the use of sludge from wastewater treatment plants for agriculture purposes is regulated by the Water Pollution Control Laws 2002-2013, the Water Pollution Control (Use of Sludge in Agriculture) Regulations of 2002 (No. 517/2002) and the Code of Good Agriculture Practice Decree (No. 263/2007). Apart from the requirements set in Directive 86/278/EEC, the Pollution Control Law requires the permitting of UWWTP. The permit includes terms related to the sludge management including its use in agriculture. Furthermore, the Code of Good Agriculture Practice includes additional requirements: (1) Prohibition of using the sludge in areas that the quality of surface waters or groundwater might deteriorate and on grassland for period of 12 months before use, (2) guidelines on sludge storage and (3) factors to be considered for determining the quantity of sludge to be applied.

United Kingdom

There is a significant amount of unintended indirect use of treated effluent occurring in the UK. Sewage effluents are used to maintain river flows and abstractions from these rivers contribute to both potable and non-potable water supplies. This occurs commonly at major rivers and provides significant volumes of water for public water supply.

There are many examples of non-potable direct treated wastewater use in the United Kingdom. Water is mostly utilised for irrigation of golf courses, parks and gardens, car washing, cooling, fish farming and industry. More than 40 percent of the total water demand in the United Kingdom is for domestic purposes. Of this amount, 30 percent is used for toilet flushing.

At this time the UK has only an emerging direct or planned reuse sector and a non-reuse specific regulatory environment. However the evidence base of reuse schemes is substantial to justify water users in the UK (water companies, agriculture, and industry) embracing reuse as a viable option in meeting demand.

Langford in the South East of England is one of only a small number of reuse schemes and the information that follows is primarily from this scheme.

UK example: Langford - Chelmsford treated wastewater as a resource

In April 2000, Essex and Suffolk Water was granted licences by the Environment Agency to discharge treated wastewater into the River Chelmer at Scotch Marsh, Essex, and to vary its abstraction to benefit from this extra water. This scheme is thought to be the first large-scale example in the UK of planned indirect reuse, where wastewater is being deliberately recycled as a drinking water resource.

Chelmsford Sewage Treatment Works is owned and operated by Anglian Water Services. It treats the sewage from about 120,000 people and has a dry weather flow of about 30 Ml/d. Treatment is primary settlement and secondary biological treatment by trickling filters and activated sludge. Anglian Water's consent limits are 10 mgN/l ammonia, 20 mg/l BOD and 40 mg/l suspended solids.

The treated wastewater from CSTW currently flows down a 15 km underground pipeline parallel to the river Chelmer and is discharged into the tidal Chelmer near Beeleigh Weir (the tidal limit). This is about one kilometre downstream of the intakes to Langford Water Treatment Works and the Raw Water Pumping Station to Hanningfield reservoir.

Under the Recycling Scheme the wastewater is taken from the pipeline into a purpose-built recycling plant at Langford for further treatment. The recycled water is then discharged into the Chelmer, upstream of ESW intakes, to augment the flow in the river and refill hanningfield reservoir for public water supply.

The Recycling Treatment Plant was installed by Degremont at a cost of £13 million, to use planned Indirect Potable Reuse Treated waste water received from Chelmsford Sewage Treatment Works. During drought periods, volumes represent up to 70 percent of the raw water available in the River Chelmer at drinking water intakes and 8 percent of the Essex water resource.

Further specifics of the scheme are found under further headings.

Turkey

Ministry of Environment and Urbanization is responsible for protecting water supplies and to approve and guide the environment protection projects. Ministry has the main responsibility about the determination of the technologies of wastewater treatment plants and their implementation.

According to the 'By-Law on Control of Water Pollution' Treated Wastewater Usage in Watering-Article 28: 'In the areas having lack of watering possibility and in which watering has got economical value, the usage of treated wastewater for watering as providing the watering quality mentioned in Communique of Technical Methods of By-Law on Water Pollution Control is encouraged. Processes for this aim and required investigations are realized on the basis of Communique of Technical Methods. Appropriateness of a wastewater for these kinds of usage is determined by a commission from Provincial Directorate of Environment, Provincial Directorate of Agriculture and Urbanization and Regional Directorate of State Water Works.'

In this direction; 'the By-Law on Urban Wastewater Treatment' was published with the purpose of pertaining to the collection of the urban and specific industrial wastewater that is discharged into the sewage, their treatment and discharge as well as its monitoring, reporting and controlling. In addition, within the scope of using urban wastewater for irrigation purpose; 'the Communique of Wastewater Treatment Plants Technical Methods' is used. Having regard to the proposal from the Advisory Committee, set up by Regional Directorate of State Water Works, Provincial Directorate of Agriculture and Provincial Directorate of Environment and Urbanization, Wastewater Discharge Permission for Treated Wastewater Usage in Watering is given by Ministry of Environment and Urbanization or Provincial Directorate of Environment and Urbanization within the scope of this Communique.

Communique of Wastewater Treatment Plants Technical Methods which came into force in 2010, regulates reuse of treated wastewater in our country.

For the purposes of this Communique is regulate the following:

- Technology selection of wastewater treatment plants,
- Design criteria,
- Disinfection of treated wastewater,
- Reuse,
- Deep sea discharge,
- Disposing of sludge.

Article 18 of the Communique: 'In the use of treated wastewaters; there are alternatives for agricultural, industrial, groundwater feeding, feedings for recreational areas, indirectly fire water, recycling in toilets and recovery as direct drinking water. The technology requirement for the recovery of wastewater is related to the intended use of the water to be recovered. If urban wastewater is to be used in agricultural or green area watering, disinfection is required. In case of direct or indirect recovery, further treatment alternatives such as membrane technology, activated carbon and advanced oxidation are required. Irrigation water criteria are given in Annex 7.'

The Table 7.1-'Classification of treated wastewater to be reused in irrigation' in Annex 7 of 'the Communiqué of Wastewater Treatment Plants Technical Methods' was adopted to Turkish Legislation from 'Guidelines for Water Reuse, 2004' which was prepared by U.S.EPA.

The Netherlands

Reuse of water is part of the general legislation and is therefore also part of the environmental permits. Companies are thus obliged to make use of the Best Available Techniques (BAT), ensuring a reduction/minimization of the companies environmental impact. Individual companies investigate (and invest in) the possibilities of reuse of waste water.

An example is the paper and pulp industry were currently 95% of the water used in the production process is treated before released back into the environment, i.e. the surface water. Furthermore, the paper and pulp industry are currently also investigating to reduce or even remove water entirely from the production process.

To stimulate the reuse of water even more, tax are raised on the use of fresh ground water while the use of reused treated waste water has a discount.
Despite these measures two major industries currently use only fresh ground water. These are agriculture and thermal energy storage in cities. These industries are in this position as there is no shortage of fresh ground water to trigger these industries to also reuse treated ground water.

The treated wastewater can be used for process water or pour water for plants. Regarding the order of discharging according article 10.29 of the environmental law the discharge in the soil or surface water after reclamation is the most preferable route.

Currently an inventory is carried out in The Netherlands towards the risk of human contamination by legionella in the wastewater treatment plants. In the light of the results of this inventory additional rules may be included in the environmental permit of respective companies.

An example of water reuse at the location of the horticulture area Nieuw-Prinsenland.
During the processing of sugar beets purified effluent of the adjacent sugar factory is converted to clean water in large quantities (figure 7). The Aquifer Storage and Recovery (ASR) in the brackish layer of the soil makes it always possible to have enough fresh water available, without the use of scarce area above gound level. The area above ground level could be used for horticulture instead of ponds or storage tanks.
The layers of the soil (geohydrological composition) is important in order to choose the best location for storage. We need:

- A thick poorly permeable top layer to protect the stored water against activities on the ground level.
- A well drained (sandy) layer of a thickness exceeding 10 metres in which the putfilters will be placed.
- A relatively low salt concentrations in the original groundwater in order to to prevent extreme losses by ramp-up and mixing.

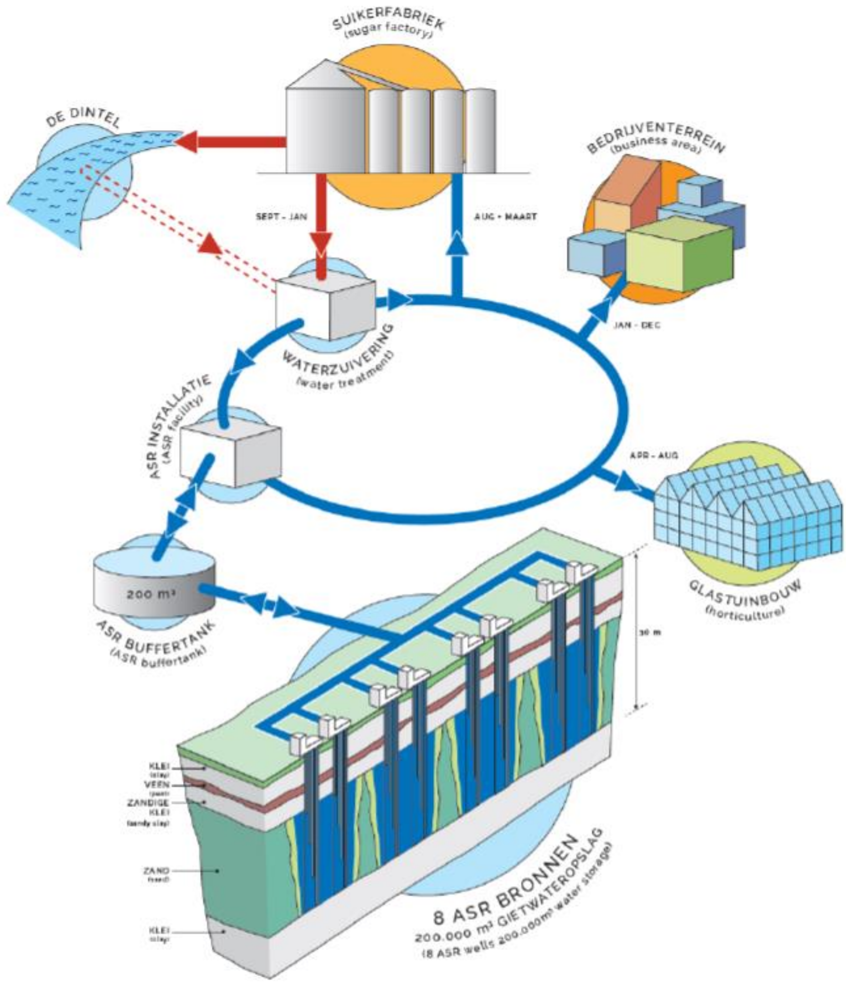


Figure 7 - Water system overview of Nieuw-Prinsenland for the supply of purified effluent to horticulture and industry after underground storage

Greenhouse water recycling, an example of implementation of environmental law in horticulture
According to the general environmental rule in horticulture, the greenhouse horticulture companies should collect and recycle condensation water of the greenhouses due to the pollution of this water with pesticides (figure 8). In this manner less pesticids could be used and the water could be reused without treatment or cleaning. Rainwater is also collected in a basin for the crops in the greenhouses.

Figure 8 - Reception of condensation water and drainage water for re-use as irrigation water

Example of water reuse in the galvanic industry
In the galvanic industry different water baths are used after electroplating in order to clean the product (figure 9). Water can be saved by using multiple steps of baths in which the last bath contains the cleanest water.

Figure 9 - Rinsing baths in the galvanic industry

By rewinding rinse water to the previous basin the amount of clean water can be reduced (figure10). An additional advantage is the limitation of raw materials (chemicals) to be add during the process.

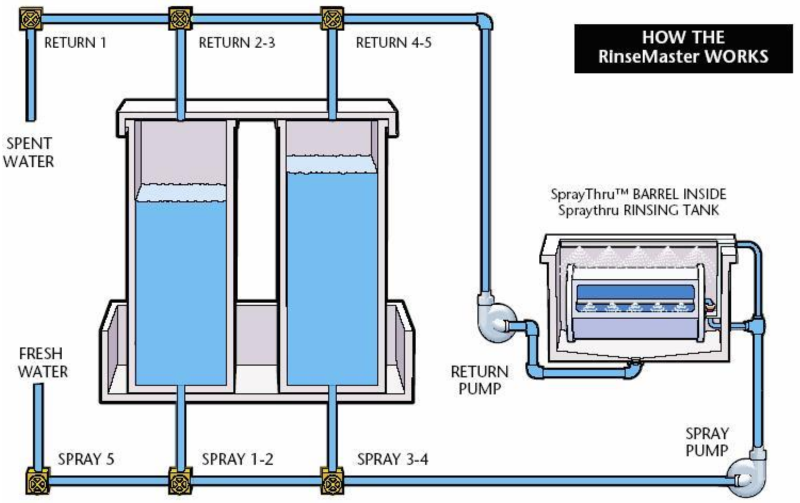


Figure 10 - The water reuse cycle

Current technologies/BATs

Italy

The term "refining" or "tertiary treatment" indicates a further stage of purification treatment to be carried out after primary treatment (primary sedimentation) and secondary treatment (i.e. aeration and secondary sedimentation) in a purification plant, with the aim of improve the characteristics of the effluent with the reuse objectives described above.
The refinement techniques that can be used are quite well established and mainly directed to the removal of the SS and the abatement of the BOD_5. The main ones use:
- microfilters;
- slow sand filters;
- quick sand filters;
- gravel filters on secondary sedimentation tanks;
- activated carbon contactors.

Microfilter
In particular cases, especially where there are great difficulties in finding areas, it is possible to use microfilters, consisting of a cylinder rotating around its axis with a peripheral speed of 0.5 m/s, on the surface of which is placed a very fine film of stainless steel (the mesh of the net can vary up to 170 holes/mm^2); the surface hydraulic load applied is between 3 and 10 m^3/h per m^2 of canvas surface. The particles of the mud, blocked by the microfilter net, are then removed by jets of purified, recycled water. The consumption of washing water amounts to about 5% of the treated water. With microfilters, yields can be obtained in the removal of suspended solids in the order of 50-60% and BOD of the order of 20-30%; the bacterial charge is not lower than 20-30%.

Slow sand filters
They consist of tanks that are placed in succession to secondary sedimentation, inside the filtering mass is formed by a layer of sand with a thickness of 50 cm to 1 m with a granulometry of 0.25-0.60 mm resting on a lower layer of gravel with a size of about 10 mm, within which a drainage pipe is placed.
The two main depurative mechanisms are:
- surface filtration: suspended solids are retained on the surface of the filtering mass and thus also a part of the polluting organic substances;
- oxidation: the granular material constitutes a biological reactor, a specific surface support extended on which the aerobic bacteria are established and developed.

The aeration takes place by means of a convection due to the displacement of the water layers; oxygen can also be introduced into the porous area through ventilation ducts. The applicable surface hydraulic load is of the order of 3-3.5 m^3/m^2 per day. The surface cleaning is necessary every 15-30 days. However, the slow filters are not free from drawbacks: they sometimes tend to get clogged and freeze during the winter, moreover for areas with a certain potential the areas of land become excessive.

Quick sand filters
The quick filters are characterized by much higher filtration rates: 100-500 m^3/m^2d, equal to 4-20 m^3/m^2h which allow to reduce considerably the surfaces required. This system has the advantage of high elasticity of operation and reduced overall dimensions.
According to the traditional approach, a quick filter consists of one or more layers of granular material, supported by a draining bottom, crossed from top to bottom by the stream of water to be filtered. The draining fund performs three functions: prevent the passage of sand with filtered water, uniformly distribute the flow during filtration and distribute the water during washing.

Filtration is carried out with a cyclic discontinuous process, the filter is kept in operation until the pressure losses due to the accumulation of impurities become excessively high, so the filtering material is "washed", in countercurrent, by an energetic flow of water (or water and air) for durations of about 15-20 min. The filter material must be of a siliceous nature, to resist the frictions created in the washing.
Sometimes flocculation is used using coagulant chemical reagents such as metallic mineral salts or polyelectrolytes as aluminum sulphate, ferrous and ferric sulphate, ferric chloride and aluminum polychloride. These products carry out destabilizing action thanks to the electropositive charge of the metal cation able to cancel the electronegative charge of the suspended colloidal particles.
Then there is the chemical coagulation-filtration treatment. With this system, compared to simple filtration, higher purification yields are obtained, in addition the removal of the bacterial load is up to 90%.

Gravel filters on secondary sedimentation tanks
These plants are used to improve the yield of the secondary sedimentation phase in removing suspended solids. The water, before leaving the sedimentation tank, is forced to pass with rising flow through a layer of gravel supported by a metallic grid consisting of a mesh with an opening of about 4mm. The yields in the removal of the SS are of the order of 50%.
Periodically cleaning is carried out by lowering the liquid level of the tank and providing an energetic washing with a countercurrent water jet.

Contactors with activated carbon
With normal filters it is not possible to obtain the elimination of micro-pollutants such as insecticides, pesticides, heavy metals, toxic substances. In this way, physical processes are used using active carbons, which generate surface attraction phenomena determined by the enormous "active" surface of the mass of the carbon, which is able to capture the particles of the above-mentioned pollutants by adsorption.
On the market there are two types of activated carbon: in powder and in granules.
The activated carbon in powder can be added upstream of the final filtration, or upstream or downstream of the oxidation tank where the inhibiting substances of the biological processes are adsorbed.
In the first case, the activated carbon remains blocked on the filter surface, and during countercurrent washing, it is returned upstream of the chemical treatment, so as to exhaust its purifying capacity before being eliminated.
In the second case, activated carbon is eliminated during the sedimentation phase.
Activated carbon in powder has difficulty in finding, and can not be recovered and regenerated.
The activated carbon in granules is suitable for systems above 100,000 PE, it is normally placed in "pressure" metal structures, similar to those seen for sand filters, with a height of about 5 m, considering a 10% free franc. to allow an expansion of the filtering mass during washing. The contact times required for the adsorption of pollutants are around 15-30 min with crossing speed of 4-10 m/h. It is always advisable that the filtration on the activated carbon is preceded by a rapid filtration on sand, to hold suspended solids, which, if blocked by the carbon filter, would cause a rapid decay of the adsorbing properties. Moreover, in cases where the use of lime is adopted in the purification processes, the sand filtration placed upstream of the activated carbon, allows the precipitation on the granules of sand of the calcium carbonate, that does not affect the purifying capacity of the activated carbon granules.
Unlike activated carbon in powder form, the granulated one can be easily regenerated with heat treatments, which happen with heating of the granules themselves at high temperature, in special ovens that cause "desorption", that is the separation from the activated carbon of the organic substances previously withheld.

Portugal

Usally, the majority of the current projects involves the disinfection stage to produce water with quality for the intendend use. The most common disinfection methods in presence are UV radiation and prior to this, usually, a filtration step is included, usually sand filtration or microfiltration. Whenever justified, a post-chlorination step is applied to prevent recontamination and/or regrowth in the distribuition systems.
The use of chlorine for primary disinfection is not recommended in Portugal due to the risk of occurrence of disinfection by-products, such as trihalomethanes.
For new projects under development, new technologies, such as, ultrafiltration membranes are start to being test. For some industrial effluents some small projects to produce water for internal uses also involve reverse osmosis.

Malta

New water is produced from the polishing of treated waste water which has till now been treated to bathing quality and disposed of in the sea. It is a three stage process comprising of (i) Ultra-Filtration (ii) Reverse Osmosis (iii) Advanced Oxidation and UV treatment. At present, lime is also being added prior to being supplied in order to increase the level of minerals.

Cyprus

Almost all the UWWTPs are equipped with tertiary treatment, consisting of sand filtration and chlorination in order to achieve higher quality characteristics to reuse the treated wastewater in

the agriculture. Some of the recent plants are equipped with advanced technologies such as membranes bioreactors and UV Disinfection.
The following table presents the treatment technologies as well as the disinfection type applied in UWWTPs that serve the urban big cities:

Table 9 - Treatment Technologies applied in big UWWTPs

a/a	Wastewater Treatment Plant	Treatment Technology	Disinfection Type
1	Anthoupoli	Tertiary treatment (Mebrane bioreactor)	UV Disinfection
2	Vathia Gonia (WDD)	Tertiary treatment (Activated Sludge – Sand Filters)	Chlorination (liquid Sodium Hypochlorite)
3	Vathia Gonia (SBN)	Tertiary treatment (Mebrane bioreactor)	UV Disinfection
4	Paralimni – Ayia Napa	Tertiary treatment (Activated Sludge – Sand Filters)	Chlorination (liquid Sodium Hypochlorite)
5	Paphos	Tertiary treatment (Activated Sludge – Sand Filters)	Chlorination (liquid Sodium Hypochlorite)
6	Limassol	Tertiary treatment (Activated Sludge – Sand Filters)	Chlorination (sodium hypochlorite/onsite generation)
7	Larnaca	Tertiary treatment (Activated Sludge – Sand Filters)	Chlorination (sodium hypochlorite/onsite generation)
8	Mia Milia	Tertiary treatment (Mebrane bioreactor)	UV Disinfection

The Rural Wastewater Treatment Plants mainly apply tertiary treatment (activated sludge - sand filtration and chlorination).

Sludge

Basically conventional treatment technologies are used for the sludge treatment. Specifically, the sludge that is used as a fertilizer in agriculture is mainly produced from four major UWWTPs using the following sludge treatment technologies:

- Thickening, Anaerobic digesters in mesophilic conditions at a temperature of 35 °C and retention time not less than 18 days leading to stabilized sludge followed by mechanical dewatering using centrifuge. Then, the dewatered sludge is transferred into drying beds for sun drying.
- Thickening, Aerobic or mesophilic anaerobic digestion followed by mechanical dewatering using filter press or centrifuge. Then, the dewatered sludge is transferred into the Sewage Sludge Drying Solar Plant.
- Thickening, followed by mechanical dewatering using centrifuge. Then, the dewatered sludge is transferred into the Sewage Sludge Drying Solar Plant.
- Thickening, Aerobic digestion for a retention time of 20 days thus ensuring that the sludge will be stabilised. The stabilised sludge with the addition of polyelectrolyte on line, is then dewatered in two centrifuges. The dewatered sludge is stored on drained hard standing drying beds prior to being spread onto land as a soil conditioner/fertiliser.

United Kingdom

Langford

Initial treatment is primary settlement and secondary biological treatment by trickling filters and activated sludge.

- Phosphate removal in a Densadeg high-rate lamella clarifier, using ferric sulphate and polyelectrolyte, with an upflow velocity of 25 m/h. Sludge is dewatered and disposed of in landfill.
- Nitrate removal in Biofor denitrifying filters (DN filters) where anaerobic bacteria convert the nitrate to nitrogen gas, using methanol as a carbon source.
- Ammonia removal in a Biofor nitrifying filters (N filters) under aeration. High BOD from the previous stage is also reduced. Biological sludges are tankered away to AWS for treatment.
- Endocrine Disrupting Compounds (EDC) levels are reduced by powdered activated carbon at the phosphate stripping stage.
- Pathogen removal by disinfection with UV light. This process was successfully trialled between July 1997 and Dec 1998 when Chelmsford disinfected treated wastewater was pumped to Hanningfield Reservoir during a severe drought.

Advanced treatment process at Langford:

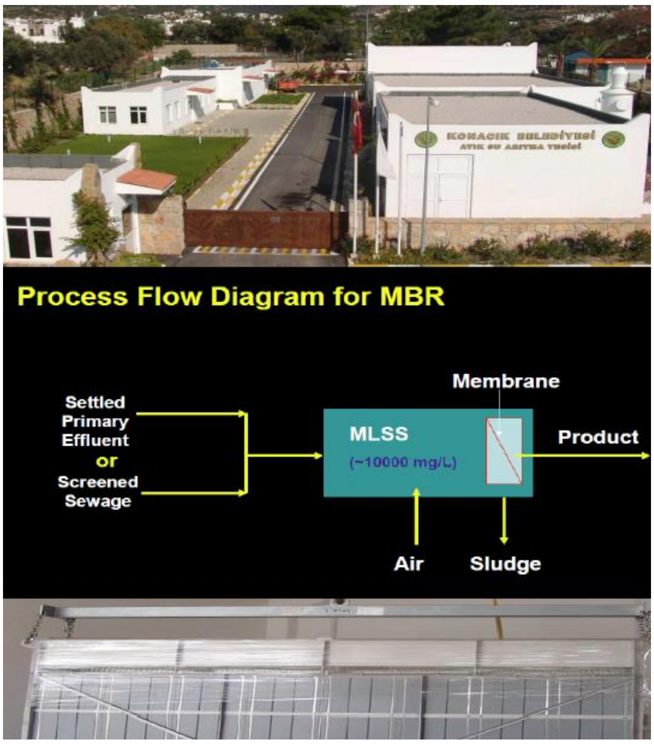
- Chemical phosphorus removal;
- Biological denitrification;
- Biological nitrification;
- UV disinfection;
- It does apply reverse osmosis treatment.

The biological process cannot be 'switched on' instantly. Typically, the system is triggered by control curves in April (warm water is required). Once the biological biomass is established it can run continuously (e.g. April to November).

Turkey

In Turkey, in the Aegean-Mediterranean region where tourism construction and investments are high; effluents from treatment plants are used for irrigation at parks and gardens and utilized in stabilization ponds for agricultural purposes. An example of MBR Application in Wastewater Treatment-Konacık Municipality (Muğla city) is given below.

- ✓ Domestic Wastewater Treatment Plant located in Konacık of Bodrum is one of the first applications using membrane technology for wastewater treatment in our country
- ✓ Recycled waters are used in park and garden irrigation and car wash facilities.
- ✓ Q=1500 m^3/day



The Netherlands

BAT consists of both measures to reduce the amount of waste water produced and measure to treat the waste water.

Examples of reduction of waste water:

- Reuse water from a previous step for another process where there is no need to use fresh water for example to clean garbage trucks.
- Reduce the steps in process where water is added to the production process, as currently investigated by paper and pulp industry

Examples to treat waste water in order to reuse the water are:

- DAF-Unit
- Precipitation
- Detoxify-Neutralisation-Dewatering
- Microfiltration
- Nano filtration

Steps in urban and industrial wastewater treatment

The regular steps in the cleaning of urban and industrial waste waters in a communal wastewatertreatment facility consists of the following steps:

The first step:

- Removal of raw materials such as toiletpaper, wood, etc
- Removal of sand
- First settlement of organic matter

The second step:

- Unaerobic treatment with active sludge
- Aerobic treatment with dissolved air

The third step:

- The removal of phosphate and nitrogen

The fourth step is not practiced in general yet. In this step the treatments of waste water could be practiced by:

- Using sandfilters
- Use of ozone
- Ultrafiltration

This step is used in order to remove medicine residues, hormones and germs. It is recogniced that these substances are becoming a more significant problem in the discharged treated wastewater.

At the moment the fouth step of reclamation is not in practice in general. The obligation of practising this fourth step by using activated carbons is stil under discussion.

Other aspects in wastewater treatment

Furthermore the removed sludge from the several wastewater treatment plants (WWTP) is collected.

The biogas extracted form the sludge after fermentation is used to generate energy. The biogas is commonly converted to electricity by using a biogas engine. In the WWTP of Amersfoort also fertilizers are extracted from the sewage sludge.

It is not allowed to use the sludge of the WWTP on agriculture land without treatment.

Expected water reuse practice

Italy

The major challenges of the Italian water service are, essentially, three: increase the treatment (4 of 10 people in Italy are not connected to a plant) and the reuse of wastewater; develop desalination systems which today supplies only 0.1% of drinking water in the Country; increase the investment on the water network to 80 € per capita per year, now standing at 32 € per capita per year.
A system of water reuse certainly has positive economic repercussions, and Italy is one of the European countries with the highest development potential. Potential not exploited, however, since primarily the industrial plants in the area are still missing: both for the purification phase and for the management of the "new water" that the purification generates.

Examples of reuse of wastewater exist in Italy, both for irrigation and for industrial purposes. The overall picture shows clear differences among Regions. However, the following general observation can be made: the use of wastewater for irrigation or industrial purposes occurred almost exclusively in situations of "water emergency", which can be classified into two groups:
- lack of water availability (mainly in the southern regions);
- high demand for water in limited portions of the territory as the presence of vast areas destined to intensive agriculture.

Only in recent years it has begun to plan the reuse of wastewater with a broader vision, taking into account the indirect advantages of this practice, such as:
- the environmental benefit of the "non-discharge";
- the possibility of not using qualitatively better waters, especially groundwater.

Barriers to the implementation of the expected water reuse practice

The problems related to the reuse of purified wastewater are:
- infrastructural: technical difficulties in the transfer of water resources seem to be one of the main reasons for the non-reuse;
- economic: the significant costs necessary to produce reuse waters and the low costs of conventional water resources possible for irrigation use, are one of the causes of the limited use of the practice of reuse in Italy;
- agronomic: the effects on the physical, hydraulic and chemical characteristics of the soil must be assessed in relation to the effects on the cultures. Often the purified wastewater has an ionic composition which is not very suitable for the characteristics of agricultural soils (sodium, calcium, magnesium, sulphates, chlorides ...);
- sanitary: the limit is not so much in the chemical parameters to be reached with the purification process, but in the bacteriological parameters. The risk, from the toxicological point of view, is related to the presence of bacteria, viruses and parasites.

Among the main issues for the reuse of urban wastewater in agriculture are:
- Lack of distribution networks and irrigated consortia with an impossibility to use wastewater although with verifiable quality;
- Salinity values (with the exception of the value especially of coliforms) not always appropriate to some types of soil for which a prior pedological and agronomic study should be done for irrigation use with these waters.

Above all the qualitative aspects linked to the quantity and quality of the salts (without prejudice to the other conditions) place serious limits on the use of these waters.
Urban wastewater has average values of electrical conductivity (with seasonal fluctuations) around 2,550 - 3,500 µS/cm, SAR values between 3 and 12, pH between 5.5 and 9.5 and the real possibility of the presence of heavy metals (such as Cr, Pb, etc.). Under these conditions, the use of wastewater without two essential conditions is unthinkable:

- The first condition is a certificate of suitability for irrigation use that can be issued only in the presence of a serious and constant monitoring of wastewater;
- The second condition is, as mentioned, a serious study of the use of wastewater taking into account some essential factors: nature of the soils and characteristics of thermopluviometric, broad-leaved, shrub-like, tree-like plants, etc.

In Italy, unlike other EU countries, the law allowing the reuse of urban wastewater and sewage sludge is different region by region, with serious complications from the point of view of logistics and the industrial process.

The technologies available today are able to produce high quality water, which can be used for any use, but it will have to deal with economic constraints. It has to be evaluated the existing infrastructure system or necessary to plan interventions in the sector, to have a complete picture of the existing purification system (type of treatments used) the adduction and distribution infrastructures to be implemented all in relation the "question" of an alternative resource expressed by users, decision-making bodies and, more generally, by public opinion.

Portugal

Currently Portugal is developing a new regulation for the use of reclaimed water for several purposes produced from domestic, urban or industrial wastewaters. Simultaneously, a new governance strategy to promote water reuse is being prepared. Also, a guideline is under preparation to clarify the all administrative process (permiting process) and the technical issues related with the conception of the project, such as the risk assessment methodologies, the choice of adequate treatment levels or the monitoring plans for reclaimed waters and environment (e.g. groundwater or surface water).
Hence is expected the new governance strategy promoting an holistic approach from the receptor (public and environment) to the reused water will rise the positive perception on the water reuse and, consenquently increase the use of treated wastewaters for several non-potable purposes.

Barriers to the implementation of the expected water reuse practice

The main barrier to overcome are the negative perception on the “use of wastewater”, which needs to be countered by robust educational campaigns and positive results from real projects that allows the evidence that is possible to treat wastewater to higher level of safety[1] that would be “a waste to use it”. Other main barriers could be land planning issues, i.e., the distance between the treatment plants and the water use site, which may is intended to overcome by the use of a planning strategy to choose the most reliable projects through the cross of the most feasible treatment systems with the suitable water use sites. Finally, the economical barriers are linked with the low price of freshwater compared with the treated wastewater, which will be address it in the new governance strategy.

[1] Including quality level and minimization measures to reduce the overall risk for human health and environment.

Malta

Reclaimed water to be used for all crops destined for human / livestock consumption, for non-food crops and for public green areas. This water will also be used in Industry as long as no direct contact is made with food, pharmaceutical or cosmetic products, such as in car wash stations, cooling towers, boilers and possibly laundries.

Barriers to the implementation of the expected water reuse practice

- Public perceptions that may drive fear of the dangers of consuming food irrigated with reclaimed water.
- Overall economic feasibility for the Reclamation Plant Operator to recover costs and subsequently work at a profit.

Cyprus

The Government of Cyprus decided the treated wastewater generated at Limassol's UWWTPs to be reused for the recharge of Akrotiri aquifer through the usage of recharge ponds. The water will be then reclaimed through pumping wells and used for agricultural purposes. In the future, according to the construction schedule of the sewage collection system, it is expected that the theoretical amount of Limassol's treated wastewater will be around 19 millions cubic meters each year.

For this purpose, a hydraulic mathematical model, simulating the aquifer's water and the dispersion of pollutants in the aquifer, based on preservatives substances such as Cl, was prepared in order to evaluate the movement of the recharged water and the pollutants into the local aquifer from the operation of the recharge ponds. A wide range of parameters and data were utilized for the generation of the hydraulic model such as groundwater levels, pumping tests, groundwater quality tests, location of wells, water extraction volumes, depth of the aquifer, geological data and recharge water volumes. Various hydraulic scenarios were examined.

The results of the hydraulic model and the calculations that were produced during the preparation of the "Environmental Impact Assessment Study for the recharge of Akrotiri aquifer with Recycled Water generated at the Limassol-Amathus Sewerage System using recharge ponds" indicated that:

- The quantity of the water that will be pumped can be almost equal to the amount of the recharge water without creating any negative impact from seawater intrusion into the aquifer or any negative effects to the Akrotiri ecosystems.
- The marine environment will not be affected by the discharge of treated wastewater in the region.
- The overall picture of the aquifer shows an improvement in some chemical parameters.

The treated wastewater produced at the UWWTP of Lemesos – Amathounta in Moni is already reused for the recharge of Akrotiri aquifer.

Cyprus also applies an aquifer recharge scheme, where reused water recharges the Ezousa's aquifer through specially constructed shallow ponds. The water, after natural purification, is used for irrigation. Pumping is carried out in a controlled way so that retention time in the aquifer is maximized.

Barriers to the implementation of the expected water reuse practice

The reuse of treated wastewater is an accepted practice in Cyprus.

In order to increase the reuse, Cyprus has developed standards that are legally binding. The quality of the reused water was set up based on the products to be irrigated. For this reason, the following considerations were taken:

Eaten raw vegetables are not allowed to be irrigated with treated effluent.
All types of irrigation system are not allowed in order to avoid the direct contact of the reused water with the products.

One of the main barriers initially was the price. This was the reason that reflected the imposition of substantial subsidies to reclaimed water supplies to encourage wider uptake.

The water reuse infrastructure is planned and constructed by the Government. The decision about the position of a wastewater treatment plant among other parameters takes into consideration whether there is agriculture in the area in order to minimise the length of the networks and the energy consumption needed for pumping the reused water.

United Kingdom

Our regulatory bodies support and encourage water companies to consider indirect effluent re-use as an option for increasing public water supply where a deficit in water supplies is forecast.

There are a number of effluent reuse schemes proposed in the current set of draft water resources management plans – see the table below. It's more likely they are indirect.

Table: Key effluent reuse information (2020-2045)

Map ref.	Company	Effluent reuse plant	Benefit to supply (Ml/d)	Build cost (£million)	Delivery time (years)	Planned delivery date
1	ANH	Pyewipe	20	294	3	2025
2	SRN	Slowhill Copse	9	37	3	2027
3	SRN	Sandown	9	17	4	2027
4	SRN	Ford	20	42	7	2027
5	SRN[1]	Peacehaven	20	63	6	2027
6	SEW[1]	Peacehaven	25	121	8	2028
7	TMS	Teddington	268	1,566	8	2030
8	ANH	Colchester	15	301	3	2030
9	SRN	Eccles Lakes	18	19	2	2035
10	SEW	Aylesford	9	36	8	2038
11	SEW	Weatherlees	15	78	8	2045

[1] The proposed Peacehaven plant is a joint scheme between SRN and SEW

(dashed box) Schemes starting in 2020-25

Barriers to the implementation of the expected water reuse practice

Human health: There are concerns that public health could be at risk indirectly if reuse water is used to irrigate crops intended for human consumption, with the risk of pathogens, or other biological and chemical agents, passing into the potable system/agricultural system and being ingested by customers.

Environment: Effluent re-use has the potential to have a negative impact on the environment if the scheme is not assessed correctly and the operation of the scheme is not well managed once implemented. Changes to water quality and river flows could result in impacts on ecology, fisheries, navigation and water available for other uses if the scheme is not well assessed and the impacts mitigated. In some cases wastewater effluent makes up a large proportion of river flows and at these locations effluent reuse could have particularly significant impacts.

Perception: There is a negative association of effluent re-use and public health concerns. There is a public perception that recycled water is less clean than water from other sources. This perception can also affect the success of effluent re-use proposals and trials. Experience in the UK on temporary reuse schemes in response to significant water shortages was surrounded by controversy from public perception and lack of any precedence, this has also resulted in the change of schemes to more indirect use.

Regulation: Currently there are no UK Regulations for Reuse schemes. The current regulations could constrain reuse projects, but new regulations could also seem quite onerous in relation to the extent of the activity in the UK.

Ownership: Indirect potable reuse (IPR) schemes inevitably involve a stage whereby the reuse water is discharged back into the environment before being ‘reclaimed, but once water is released to the environment someone else has a claim to it, this could cause ownership issues.

Carbon and scheme costs: Carbon and greenhouse gas operating emissions tend to be higher for effluent re-use than for other comparable water supply options due to the process of reverse osmosis that is often used to treat wastewater for re-use. Reverse osmosis treats water to a very high level, but is energy intensive and therefore may be costly and result in high carbon emissions. High carbon costs influence the cost assessment through options appraisal where financial, environmental and social costs are considered. For this reason, effluent re-use may be better suited to meeting short-term peak demands by supporting other water supply actions, especially if reverse osmosis is required.

The Netherlands

In The Netherlands the development of reuse of especially urban waste water is going fast, due to the circular economy. All boards of government bodies involved with water in The Netherlands work together on investigating ways of recovering useful constituents from urban waste water.
The developments on reuse of waste water focusses on use of different constituents of urban waste water such as:

- Paper from cellulose
- Phosphate for use in fertilizer
- Protein for use in (pet)food (is not permitted at this time)
- Making energy from sludges
- Use of rough materials in new products

All waterboards in The Netherlands are investigating ways of recovering useful constituents from urban waste water.
However, the most of these are not permitted due to current European legislations.

Barriers to the implementation of the expected water reuse practice

Barriers for implementing some ways of reuse of (parts of) waste waters are:

- Legislation on food safety currently does not allow reuse of products from urban wastewater recovery. Reuse of products such as protein in food products are not permitted because of the possible impact on the food chain.
- European and local legislation on the reuse of treated urban wastewater labels treated industrial and urban waste water as waste and not as a raw material. Therefore, reuse is only possible after an 'End Of Waste' procedure.
- Medicine-residues and hormones in the treated waste water.

Economicly feasible techniques in order to clean the water to a safe standard.

Current quality requirements

Italy

Italian regulations describe several urban, agricultural and industrial uses. Reclaimed water could be used for all crops destined for human/livestock consumption, for non-food crops and for public green areas (even sport facilities). Industrial use is allowed if no direct contact is made with food, pharmaceutical or cosmetic products. The characteristics and limit values for industrial reuse shall be set by the parties concerned depending on the requirement of the industrial process and they should, as a minimum, comply with the limit values set out for water discharges to surface water (table 3 of annex 5 to part III of the Legislative Decree 152/2006, article 4 of the 2003 regulation).

The specific regulation for Italy is summarized in the following table (D.M. 185/2003).

Table 10 - D.M. 185/2003

PARAMETERS	STANDARDS	PARAMETERS	STANDARDS
pH	6.0 ÷ 9.5	Sulphites [mg SO_3/L]	0.5
Sodium Adsorption Rate	10.0	Sulphates [mg SO_4/L]	500
Coarse solids	absent	Chlorine residual [mg/L]	0.2
TSS [mg/L]	10.0	Chlorides [mg Cl/L]	*250*
BOD_5 [mg/L]	20.0	Fluorides [mg F/L]	*1.5*
COD [mg/L]	100.0	Animal/vegetal oils & fats [mg/L]	10.0
Phosphorus [mg P/L] (total)	2.0	Mineral oils [mg/L]	0.05
Total Nitrogen [mg N/L]	15.0	Phenols [mg/L] (total)	0,1
Ammonia [mg NH_4/L]	2.0	Pentachlorophenol [mg/L]	0.003
EC_W [dS/m]	3.0	Aldehydes [mg/L] (total)	0.5
Aluminium [mg Al/L]	1.0	Tetra/tricloro-ethylene [mg/L]	*0.01*
Arsenic [mg As/L]	0.02	Chlorinated solvents [mg/L] (total)	0.04
Barium [mg Ba/L]	10.0	TTHM [mg/L]	*0.03*
Boron [mg B/L]	*1.0*	Aromatic solvents [mg/L] (total)	0.001
Cadmium [mg Cd/L]	*0.005*	Benzene [mg/L]	0.01
Cobalt [mg Co/L]	0.05	Benzo(a)pyrene [mg/L]	0.00001
Chromium [mg Cr/L] (total)	0.1	Org. nitr. solvents [mg/L] (tot.)	0.01
Chromium VI [mg Cr_{VI}/L)	0.005	Surfactants [mg/L] (total)	0.5
Iron [mg Fe/L]	2.0	Chlorinated biocides [mg/L]	0.0001
Manganese [mg Mn/L]	0.2	Phosphorated pesticides [mg/L]	0.00001^
Mercury [mg Hg/L]	*0.001*	Other pesticides [mg/L] (total)	*0.05*
Nickel [mg Ni/L]	0.2	Vanadium [mg V/L]	0.1
Lead [mg Pb/L]	0.1	Zinc [mg Zn/L]	*0.5*
Copper [mg Cu/L]	*1.0*	Cyanides[mg CN/L] (total)	*0.05*
Selenium [mg Se/L]	*0.01*	Sulphides [mg H_2S/L]	0.5
Tin [mg Sn/L]	3.0	*E. Coli* [UFC /100 mL] *(80% of samples)*	10*
		CWs & Stabilisation ponds	*50***
Thallium [mg Tl/L]	0.001	*Salmonellae* [UFC /100 mL]	absent

^ for any single item;
** 100 CFU/100 mL will be allowed as a maximum for a single isolated sample and for the first three years of application of the new Act;*
*** 200 CFU/100 mL will be allowed as a maximum for a single isolated sample.*

Italian regulations include *Salmonella* sp. analysis as a compulsory parameter for all the intended uses, requiring total absence of the pathogen.
Italian standards include maximum limit values for physical-chemical parameters that have to be met for all the intended uses of reclaimed water. Some parameters have limit values similar to those designated for drinking water, even if the reclaimed water is used for uses such as irrigation of green areas.
The Italian regulation applies the same water quality limits for all uses of reclaimed water aside from industrial uses. Limit values for industrial reuse are set by the parties concerned depending on the requirement of the industrial process. This approach does not consider the different risks

associated with each particular use, and it is not consistent with the later approach recommended by the WHO (2006).

According to the maximum limit values established for microbiological parameters, the Italian standards are the most stringent considering the E. coli limit value. In the Italian decree, the limit value for E. coli of 10 cfu/100ml (in 80% of the sample in the year) is binding for irrigation and civil uses, although a value of 100 cfu/100ml can also be allowed in certain cases.
Regarding industrial uses, limit values should, as a minimum, comply with the limit values set for water discharges to surface water (table 3 of annex 5 to part III of the Legislative Decree 152/2006, article 4 of the 2003 regulation).
Table 3 does not set binding standards for E. coli, although a limit of 5 000 cfu/100ml is suggested (for discharges to surface water, the competent local authority sets E. coli limits for each discharge permit depending on the environmental status of the water body, sanitary conditions and possible downstream uses).

In Italy, standards under national legislation are stricter than those presented in the JRC draft report on minimum quality requirements for water reuse (with the exception of BOD) (JRC, 2017) and more stringent than the EU guidance document on addressing microbiological risks based on the fecal indicator organism threshold value for *E. coli* (EU Commission, 2017).

The maximum allowable concentrations for many chemical constituents are limited more by the needs of agricultural crops than by the real risks to human health.
The nutrients, nitrogen, phosphorus, potassium, zinc, boron and sulfur, must be present in the treated wastewater in the correct concentrations otherwise they can damage both the crops and the environment. For example, the amount of nitrates needed varies in different stages of plant development, while during the growth are necessary high amounts of nitrates, these are reduced during the flowering phase. Control over nitrate concentrations is essential to reduce leaching in aquifers which represents a potential risk of water pollution for human consumption.
Sodium, chloride, boron and selenium concentrations should be carefully controlled due to the sensitivity of many plants to these substances.
Selenium is also toxic based on concentrations and boron is found in high concentrations due to the presence of detergents in wastewater. Water quality is also an aspect to consider when choosing the irrigation system. In conditions of high temperatures and low humidity, when evapotranspiration is favored, the use of rain irrigation is not recommended if the waters contain high concentrations of sodium and chlorides as they can cause damage to the leaves.
Trace elements with threshold values for agricultural production below which the toxicity to plants is considered acceptable are also considered.

Portugal

For irrigation purposes, currently Portugal is already using the quality requirements proposed in the ISO 16075, which were the base for the new European Regulation requirements for agriculture irrigation. Therefore, a fit-for purpose approach is already being applied and for new projects, a risk assessment is starting to be asked. To each irrigation project, according the end-uses, a class A, B, C or D is proposed combined with several minimization measures, i.e., multi-barriers, to avoid or minimize the risk of contact between crops and water and between people and water. The barriers are choosen according the principle of equivalent barrier as described on the ISO 16075, EPA and WHO standards. Usuallly, the Portuguese health authorities do not allow the use of reused water for the irrigation of crops with edible parts that are in contact with the irrigation water and may be consumed raw.

For each project, a dedicated monitoring plan is proposed which includes reused water and, whenever justified, relevant water bodies (groundwater and/or surface water). Monitoring parameters are chosen according the reused water quality requirements and the status and uses of water bodies.
Whenever a post-chlorination stage is in place, the monitoring of trihalometanes, namely chloroform, is required.

Malta

Malta produces Class A reclaimed water which can be used for all food crops , including root crops consumed raw and food crops where the edible past is in direct contact with reclaimed water. All irrigation methods are permissible. Quality requirements are as follows (i) E. coli ≤10cfu/100ml, (ii) BOD5 ≤10 mg/L, (iii) TSS ≤10mg/L, (iv) Turbidity ≤5 NTU, (v) Legionella spp. <1000cfu/l where there is a risk of aerosolization in greenhouses and (vi) Intestinal nematodes (helminth eggs) ≤1 egg/l for irrigation of pastures or forage.

Cyprus

The quality requirements for treated water used for irrigation usually depends on the type of discharge, the quality of the relevant waterbody, the corps irrigated, the sensitivity of the area and the size of the UWWTPs.

Uwwtps ≥ 2.000 p.e
Some of the main parameters that are monitored as regards the uwwtps ≥ 2.000 p.e are: BOD_5, SS, TN, TP, conductivity, pH, heavy metals, B, Cl, E. Coli and toxicity. Usually, the limit values set for total nitrogen and total phosphorus are15 mg/l and 10 mg/l respectively.

Further monitoring obligations are set in the permits when the tertiary effluent is recharged in aquifer or discharged to surface waters (dam or sea) taking into consideration the standards specified to Groundwater Directive 2006/118/EC and Directive 2008/105/EC regarding Environmental Quality Standards respectively. Additionally, discharges from urban waste water treatment plants to sensitive areas (water bodies which are eutrophic) meet more stringent requirements related to TN and TP. In such cases the limit values can be TN=10mg/l and TP=1mg/l.

Small uwwtps ≤ 2.000 p.e

The treatment requirements of small – scale wastewater treatment are also implemented via the Water Pollution Control Law as well as Regulations and Ministerial Decrees.

According to the Ministerial Decree of small – scale wastewater treatment plants ≤ 2.000 p.e (No. 379/2015), the quality requirements for treated water used for irrigation are the following:

Table 11 - Treatment Requirements for Irrigation

a/a	Irrigation	BOD_5 mg/l (every 1 month)	COD mg/l (every 1 month)	SS mg/l (every 1 month)	E. Coli / 100 ml (every 1 month)	pH (every 1 month)	Conductivity μS/cm (every 1 month)	Cl mg/l (every 1 year)	B mg/l (every 1 year)	Residual chlorine mg/l (every 1 month)
1	All crops and	10	70	10	5	6,5-8,5	2.500	300	1	2

	green areas (a)									
2	Vegetables eaten cooked (b)	10	70	10	50	6,5-8,5	2.500	300	1	2
3	Products for human consumption and green areas with limited access to the public	25	125	35	200	6,5-8,5	2.500	300	1	2
4	Crops for animal feed	25	125	35	200	6,5-8,5	2.500	300	1	2
5	Industrial plants	25	125	35	200	6,5-8,5	2.500	300	1	2

(a) Not for strawberries, leafy vegetables, bulbs and condyles eaten raw.
(b) Potatos and beetroots.

Further monitoring obligations are set in the above Decree when the tertiary effluent is discharged to underground waters (during the winter period) taking into consideration the standards specified to Groundwater Directive 2006/118/EC.

United Kingdom

No effluent reuse specific regulations exist in the UK. The most important pieces of legislation which directly affect effluent reuse are the Urban Wastewater Treatment Directive, the Water Framework Directive and the DWI regulations for drinking water.

In setting the consents, the Environment Agency require that all river quality standards are met and that there is no deterioration in river water quality caused by the discharge of recycled wastewater, and ongoing water quality permitting and regulation to ensure water quality standards are maintained, particularly where the water is recycled for potable use.

Effluent re-use schemes which do not discharge via a water body would be regulated as part of the waste management regime, the UK does not have any of these schemes.

There are currently no formal UK guidelines on the quality of water that can be used in agricultural irrigation. However in the UK most farmers irrigating field crops (majority of agricultural irrigation) use water abstracted directly from surface or groundwater sources, rather than potable mains water.

Langford
At the Chelmsford Sewage Treatment Works consent limits are 10 mgN/l ammonia, 20 mg/l BOD and 40 mg/l suspended solids. The table below shows the mean of three important water quality parameters used.

Parameter	Unit	River	Recycled water
Phosphate	**µg/l**	**467**	**76**
Nitrate	**mg/l**	**37.3**	**22.9**
E. coli	**/100ml**	**450**	**86**

Table *: Water quality in the river and the recycled water from Langford Recycling Plant

The discharged treated water meets the water quality standards (as set by the WFD). The treated reclaimed water from Langford is consistently much higher quality than the receiving river water in terms of chemical and bacteriological contaminants. The treated reclaimed water meets all established water quality standards set by the UWWD and as such, Langrord is considered the tertiary stage of the Chelmsford Sewage Treatment Works.

Turkey

Communique of Wastewater Treatment Plants Technical Methods Table E7.1 defines the Criteria for Treated Wastewater Usage for Irrigation and categorizes treated wastewater in Class A and Class B. According to the category, irigation of certain types of plants and areas can be permitted. In addition to Table E7.1, Table E7.2 defines chemical quality of irrigation water.

Table E7.1 and Table E7.2 are given below:

Table E7.1. Classification of treated wastewater to be reused in irrigation

Type of reuse	Type of treatment	Quality of reclaimed water[a]	Monitoring period	Applicable distance[b]
		Class A		
		a-Agricultural irrigation: Food products that are not commercially processed[l] *b-Irrigation of urban areas*		
a) **A**ll food products irrigated with **s**urface and sprinkle irrigation and directly consumed raw **b)** All kinds of green spaces (parks, golf courses etc.)	-Secondary treatment[c] -Filtration[d] -Disinfection[e]	-pH=6-9 -BOD_5 < 20 mg/L -Turbidity < 2 NTUf -Fecal coliform: 0/100 mL[g,h] -In some cases analysis for specific virus, protozoa and helminth can be required. -Residual chlorine > 1 mg/L[i]	-pH: Weekly -BOD_5: Weekly -Turbidity: Continuous -Coliform: Daily -Residual chlorine: Continuous	Must be at least 50 m away from wells which provide drinking water
Additional information: *-For agricultural irrigation, attention should be given to heavy metal analysis.* *-In order to reach the standards coagulation can be added before filtration.* *-Treated wastewater that will be reused should be colorless and odorless.* *-In order to destroy virus and parasites, longer disinfection contact periods can be applied.* *-Residual chlorine should be more than 0.5 mg/L in the treated wastewater distribution system (at the final application).* *-High nutrient levels can affect food products during growing.*				
		Class B		
		a- Agricultural irrigation: Food products that are commercially[m] *b-Irrigation areas where entrance is restricted* *c- Agricultural irrigation: Plants that are not food products*		
a) Fruit gardens and vineyards where products are irrigated with surface irrigation **b)** Production of grass and cultivation areas where entrance of people is restricted	-Secondary treatment[c] -Disinfection[e]	-pH=6-9 -BOD_5 < 30 mg/L -SS < 30 mg/L - Fecal coliform < 200 ad/100 mL[g,j,k] - In some cases analysis for specific virus, protozoa and helminth can be required.	-pH: Weekly -BOD_5: Weekly -SS: Daily -Coliform: Daily -Residual chlorine: Continuous	- Must be at least 90 m away from wells which provide drinking water. -If sprinkler irrigation is applied, it should be at least 30 m away from people

c) Forage crops for grazing animals	- Residual chlorine > 1 mg/L[i]

Additional information:

-Limits for agricultural irrigation should also be considered.

-If sprinkler irrigation is applied, SS should be lower than 30 mg/L.

- High nutrient levels can affect food products during growing.

-Dairy cow should not be allowed in the forage for 15 days after irrigation. If this time needs to be shorter, fecal coliform should be at most 14 / 100 mL.

Table E7.2. Table for the assessment of chemical quality of irrigation water

Parameters		Units	Damage degree: Non (I. class water)	Low – medium (II. class water)	Dangerous (III. class water)
Salinity					
Conductivity		µS/cm	< 700	700-3000	>3000
Total dissolved solids		mg/L	< 500	500-2000	>2000
Adsorption					
SAR_{Tad}	0-3	EC	≥ 0.7	0.7-0.2	< 0.2
	3-6		≥ 1.2	1.2-0.3	< 0.3
	6-12		≥ 1.9	1.9-0.5	< 0.5
	12-20		≥ 2.9	2.9-1.3	< 1.3
	20-40		≥ 5.0	5.0-2.9	< 2.9
Specific ion toxicity					
Sodium (Na)					
Surface irrigation		mg/L	< 3	3-9	> 9
Microirrigation		mg/L	< 70	> 70	
Chloride (Cl)					
Surface irrigation		mg/L	< 140	140 –350	> 350
Microirrigation		mg/L	< 100	> 100	
Boron (B)		mg/L	< 0.7	0.7-3.0	> 3.0

Table E7.3, Table E7.4, Table E7.5, and Table E7.6 of the Communique also provides information on the sensitivity of the plants that will be irrigated with treated wastewater.

The Netherlands

In the Netherlands we do not have standard requirements for the reuse of treated waste water. The reuse of treated waste water is not allowed by law.

Risk assessment (examples and applied methodologies)

Italy

The risk management framework is not mentioned in Italian regulation as a tool to be applied by the Country, but additional physico-chemical parameters are considered such as heavy metals, nutrients and organic substances.

Portugal

Portugal is preparing a new regulation for water reuse for several purposes besides the agriculture irrigation in which a risk management approach will be embed. However, the current permitting process already applies part of this concept, namely on the combination between the intended uses and the correspondent definition of specific quality parameters, souring environment and application of multiple barriers to minimize the contact the contact of the water with human receptors or minimize pathways between the reused water and water resources. Also, some research work is being conducted under the semi-quantitative approaches for non-potable uses, such as the one described by Rebelo last March, in the 14th National Water Congress, supported on importance scales and in the water microbiological content (Rebelo, 2018)[2].

Malta

The Water Services Corporation, being the reclamation plant operator for Malta, shall draw-up a Water Reuse Risk Management Plan based on key risk management tasks. These include: (1) Description of the current water reuse system; (2) Identification of potential hazard (such as the presence of pollutants and pathogens) and the potential for hazardous events; (3) Identification of the environments, populations and individuals at risk of exposure to the potential hazards; (4) an assessment of the environmental risks and risks to human health; (5) additional monitoring of the quality of the water vis-à-vis the levels of heavy metals, pesticides, disinfection by-products, pharmaceuticals etc; (6) Identify all preventive measures that need to be implemented in order manage all potential risks; (7) Ensure that adequate quality control systems and procedures are in place; (8) ensure that environmental monitoring systems are in place that will detect any negative effects and (9) ensure that an appropriate system is in place to manage incidents and emergencies.

The Water Reuse Safety Plans must cover the whole system, from the Water Reclamation Plant to the point of use.

Current use of reclaimed water supplied by the Water Services Corporation is regulated by the Food Safety Commission.

Cyprus

According to the Environmental Impact Assessment Law, the Technical Committee assess the potential environmental effects of planned developmental activities related to the design, construction and operation of Sewerage Systems and Urban Waste Water Treatment Plants as well as the Management of the treated wastewater to identify and evaluate the positive and negative

[2] Only available in Portuguese language.

impacts to the environment and to the public health. An Environmental Approval is issued by the Department of Environment setting specific terms for the protection of Environment.

United Kingdom

From an environmental perspective key issues to consider:

1. The impact on downstream ecology of re-abstracting effluent which would otherwise have supported downstream flows (important at low flows); a. impact on flow dependent habitats and species; b. impact on capacity to dilute contaminants within the environmental water sourced from the river catchment.

2. The impact on downstream abstractors of re-abstracting effluent which would otherwise have supported downstream flows (important at low flows). This raises the important issue of ownership, which is yet to be addressed and resolved by the Government and regulator.

3. The water quality of treated effluent that has already been through the reuse cycle at least once. Depending on how tight the reuse cycle is, and the substances contained within the wastewater, accumulations can develop within effluent discharges. There will also be concentrated treatment residues requiring disposal;

These risks would need to be addressed but would be covered by the existing abstraction licensing and discharge permitting arrangements in advance of scheme development and operation.

The Environment Agency would need confirmation that all the relevant standards in the WFD, including no deterioration at both the discharge point and the point at which the water is re-abstracted would be met:

Environmental impact assessment and options appraisal of any proposed effluent reuse scheme is important to protect the environment and other interests from any negative impacts of changes to the flow regime and water quality that effluent re-use may cause. Looking at the costs and benefits to provide recommendations to minimise negative impacts. An appropriate risk-based approach to water quality monitoring and wastewater catchment characterisation will be required to inform decisions on potable water quality testing.

Langford
The Blackwater Estuary, from where water is diverted to the Langford scheme is a Site of Special Scientific Interest, a Special Area of Conservation and a Special Protection Area.

Environmental impact assessments consisted mainly of studies on marine invertebrates and wildfowl. Increased water abstraction can increase siltation levels which is a particular problem for boat users and the local port. To mitigate this ESW dredges Maldon Port annually, even though the Scheme only operates during dry years.

Lessons learned from Langford - Extensive risk assessment and mitigation exercises are critical as protecting human health and environmental systems is paramount.

Turkey

Risk assessment framework is not mentioned in Turkish regulation as a tool to be applied by the country.

The Netherlands

In the Netherlands there are no standard requirements for risk assesment for the reuse of treated waste water. The reuse of treated waste water is commonly not allowed.

We do not have large water scarcity problems. There are, however, regional water scarcity problems. The scenarios of the “Delta program fresh water” show that this in the future, among other things, by climate change will increase. There is no specific policy that Dutch quality demands on the treated waste water with application of irrigation water in agriculture. The treated waste water meets the requirements of the urban waste water directive.

Monitoring

Italy

The Italian standards do not consider a frequency of analysis. This frequency should be established by those responsible for the facility, in accordance with the authorities and always taking into account the variability of water characteristics.
The Italian standards include the approval of the public health authorities for several uses, issuing the permit on a case-by-case basis.

Some of the most important chemical-physical characteristics to be controlled to determine the suitability of agricultural use of wastewater are the following:
• pH
• salinity
• sodium (sodium absorption ratio or SAR)
• carbonates and bicarbonates in relation to the content of Ca and Mg
• other trace elements
• toxic anions
• nutrients
• free chlorine

A monitoring program could provide for a qualitative control of the new waters before distribution and in irrigated parcels, with analysis of irrigated soil and fruit.
The following are the possible checks that can be carried out:
a) Analysis of the water in the outlet of the tertiary treatment;
b) Analysis of irrigated parcels (the closest and most distant from the plant and others sampling points to be established);
c) Analysis of soil and fruit.

The outgoing analysis of tertiary treatment are already indicated in Ministerial Decree 185/2003.
The analysis to the irrigated parcels can be:
- ✓ Microbiological (fecal coli, total coli, fecal streptococci);
- ✓ Chemicals (chlorine/residual peracetic acid, COD, SAR, suspended solids).

Regarding soil analysis can be:
- ✓ Chemical-physical analysis of soils on samples taken at the beginning and at the end of the irrigation season, for example:

- pH
- Organic substance (%)
- Organic carbon (%)
- Total nitrogen (%)
- assimilable phosphorus (ppm P_2O_5)
- assimilable sodium (mEq/100gr Na)
- Potassium assimilable (mEq/100gr K_2O)
- Sand (%)
- Limo (%)
- Clay (%)

- ✓ Microbiological analysis of the soil on samples taken at the beginning and at the end of the irrigation season:

- Total coliforms (UFC/100 ml)
- Faecal coliforms (UFC/100 ml)

- Faecal streptococci (UFC/100 ml).
Soil analysis should be carried out at the beginning and end of the irrigation season to evaluate possible changes in the chemical and physical structure (possible accumulation of heavy metals, increase in salinity, etc.).

Regarding the analysis of agricultural products can be:
Microbiological analysis of agricultural products (i.e. fruits) at the time of harvest (which occurred at three different times of the crop cycle) and after 7-13 days storage:
- Total coliforms (UFC/100 cm^2);
- Faecal coliforms (UFC/100 cm^2);
- Faecal streptococci (UFC/100 cm^2);
- Presence of Salmonella;
- Presence of Vibrions;
- Presence of helminth eggs.
Furthermore, if the purified wastewater is destined to irrigate green spaces open to the public (golf courses, gardens, flowerbeds), microbiological analysis could be performed on the grass.

Portugal

Each permit is delivered by the water authority and defines a compliance or verification monitoring program that is specific for each project according the requirements for end-uses and the characteristics of the surrounding water bodies, namely status and uses. For the establishment of these programs, a formal approval from the health and agriculture authorities is needed, namely for agriculture irrigation, or just from the health authority for public areas irrigation. These programs can include the treated wastewater and surface or groundwater. The typical parameters asked are:

- Public area irrigation: E. coli, helminth eggs, trihalomethanes (e.g., chloroform) if residual chlorine is applied in the distribution systems, BOD_5, COD, TSS, salinity and nutrients;
- Agriculture irrigation: Same as above plus SAR, salinity and some heavy metals according crops (some metals presents specific toxicity for certain types of crops);
- Protection of water bodies: Monitoring of surface or groundwater (e.g., E. coli, nitrates, phosphorous, TOC).

If needed the agriculture authorities may define the need of crops and/or soil monitoring.

Operational parameters are defined by operators to control treatment and distribution systems and usually includes turbidity, dissolved oxygen, residual chlorine, etc.

Validation monitoring is not yet performed in Portugal since, currently, the Portuguese health authorities do not allow the use of reclaimed waters for the irrigation of crops that may be consumed raw and have edible parts that may directly contact with the water.

Malta

Reclaimed water is currently being analysed for E.coli, BOD5, TSS, Turbidity and Legionella spp. twice a week. Moreover, the water being produced after each process, i.e. ultrafiltration, reverse osmosis and advanced oxidation is also regularly monitored.

Further parameters, including a number of organics, emerging pollutants, pesticides and metals are also regularly analysed for polished water.

Cyprus

- Monitoring include the sampling and analyses of chemical, physical and microbiological parameters of the treated wastewater such as:

  - BOD5
  - COD
  - SS
  - Heavy metals
  - Phosphorous and Nitrogen
  - Residual Chlorine
  - Priority Substances
  - Pathogens

  a) The provisions of the following legislation are considered to set up monitoring terms depending on the type of the discharge and the related water body:

  - UWWTD 91/271/EC.
  - «Guidance Document for the implementation of the European PRTR». Indicative sector specific sub-list of water pollutants.
  - Groundwater Directive 2006/118/EC.
  - Directive 2008/105/EC regarding Environmental Quality Standards.
  - «Ministerial Decree of small – scale wastewater treatment plants ≤ 2.000 p.e (No. 379/2015).
  - The Code of Good Agriculture Practice Decree (No. 263/2007).

  b) The quality/quantity of the treated wastewater as well as the quality of the waterbody and/or the corps irrigated are also considered.

- Further monitoring obligations are set up in the permit for the monitoring of the groundwater and soil in the irrigated area, as well as the surface water and the aquifer if its relevant.

- An example is given for the UWWTP of Lemesos – Amathounta ("Case Study: UWWTP of Lemesos - Amathounta").

United Kingdom

The Langford Risk assessment and mitigation required years of baseline data for the reuse scheme to be successful.

Ten years of environmental monitoring preceded the opening of the Scheme. Demonstrating that the Scheme will comply with WFD objective of "no deterioration".

Turkey

Communique of Wastewater Treatment Plants Technical Methods Table E7.1 defines the Criteria for Treated Wastewater Usage for Irrigation and categorizes treated wastewater in Class A and Class B. According to the category, irrigation of certain types of plants and areas can be permitted. Table E7.1, Table E7.2 of the Communique defines monitoring frequencies as follows:

Class A:

- -pH: Weekly
- -BOD_5: Weekly
- -Turbidity: Continuous
- -Coliform: Daily
- -Residual chlorine: Continuous

Class B:

- -pH: Weekly
- -BOD_5: Weekly
- -SS: Daily
- -Coliform: Daily

-Residual chlorine: Continuous

The Netherlands

In the Netherlands are no standard requirements for the monitoring of reuse of treated waste water. The reuse of treated waste water is commonly not allowed.

Water Reuse Costs

Italy

In 2012 ISPRA has published a Survey model for the assessment of the feasibility of the reuse of treated wastewater.
The model, divided into 5 chapters, reports in the first two the results of the identification of criteria, indicators and indexs that led to the formulation of the evaluation model. The methodology developed was applied and verified on 10 case studies, described in the third chapter, while in the fourth, "Technical and economic feasibility of reuse", the results emerged from the examination of the ten plants studied, which allow to highlight the strengths and weaknesses.
In the last chapter the definition of the criteria for the preparation of a plan to monitor the quality of the treated wastewater and the environmental effects/benefits that may derive from reuse is presented.
The choice of the 10 case studies was carried out with the intention of examining different cases in order to: reuse methods (direct agricultural, indirect agricultural, industrial); size of the wastewater treatment plant (reused or reusable flow rates between 5,000 and 115,000 m^3/d); geographical location; fact of reuse (in anticipation or in progress).
The application of the evaluation criterion to the purification plant of Baciacavallo (Prato), which is one of the case studies taken into consideration, leads to the following conclusions:

- from the economic point of view, a particular mechanism of tariff for supply and purification service makes the reuse of purified water sustainable;
- the purification, followed by refining and mixing with water taken from the Bisenzio river, guarantees a level of quality compatible with reuse in the textile sector. The tertiary treatment system also guarantees the reliability of operation and therefore the stability of the performances;
- the availability of recycled water is positively assessed also from the user's point of view, in relation to the aspects of availability and the quality level of the resource. Overall, therefore, the evaluation criterion adopted, leading to a positive judgment for all the aspects considered, confirms the feasibility of reuse, which, moreover, has already been carried out for some years. It should be emphasized, however, that an incentive/pricing mechanism has been adopted, which distributes the costs of reuse also on users who do not use this opportunity. This was essential to guarantee the economic sustainability of the operation.

The average costs for reuse, as calculated by ISPRA in a Survey of several Italian recycling plants (different plants for different uses: urban, industrial, agriculture) range between 0.0083 and 0.48 €/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 €/m^3.
The high cost of recycled water is generally indicated as one of the main barriers to water reuse.

Portugal

Available data is currently insufficient to generate scenario based cost ranges that would provide reasonable indicative capital or operating costs.

Malta

In every period of one year, the service charge and the tariffs for water consumption of highly polished reclaimed water shall be as follows:

(a) the service charge in respect of access to highly polished reclaimed water distribution system shall be €25;
(b) the tariff for highly polished reclaimed water consumption shall be as follows:

(i) for any quantity not exceeding 2,500m^3 ....€0.20 per 1m^3;

(ii) for any quantity exceeding the said quantity of 2,500m^3 but not more than 5,000m^3 ..€0.60 per 1m^3;

(iii) for any quantity exceeding the said quantity of 5,000m^3 ....€0.80 per 1m^3.

Provided that the tariff related to the first block of 2,500m^3 for all consumers of highly polished reclaimed water for agricultural purposes shall be free of charge until such time as when the Minister responsible for the Water Services Corporation so orders that the tariff found in sub-paragraph (i) enters into effect: Provided further that the tariff bands which shall be applicable on a per holding basis for the highly polished reclaimed water supplied for agricultural purposes shall be as follows:

Holding Size (ha)	Holding Units	Volumetric quantity for which the lowest tariff rate shall be applicable (m^3)	Volumetric quantity for which the highest tariff rate shall be applicable (m^3)
≤0.50	1	2,500	5,000
0.51-1.00	2	5,000	10,000
1.01-1.50	3	7,500	15,000
1.51-2.00	4	10,000	20,000
2.01-2.50	5	12,500	25,000
2.51-3.00	6	15,000	30,000
3.01-3.50	7	17,500	35,000
3.51-4.00	8	20,000	40,000
4.01-4.50	9	22,500	45,000
4.51-5.00	10	25,000	50,000
5.01-5.50	11	27,500	55,000
5.51-6.00	12	30,000	60,000

For holding units in excess of 6 ha, the volumetric quantities for which the tariff rates shall be applicable shall be calculated on a *pro rata* based on the per-holding unit allocation.".

1 holding = 0.5Ha of land for agricultural purposes

(*) Government incentive which can be revised is that the first rate for agriculture is free

Non-Agriculture use is considered as rate for 1 holding.

Cyprus

In Cyprus, from the very beginning, reused water was supplied for irrigation at a price that is 33% to 40% of that paid for conventional freshwater (fresh water price was €0.17/m^3 for agriculture and €0.34/m^3 for landscape, while the recycled water price was €0.07/m^3 and €0.15 respectively).

This was a strong incentive for the users to accept reused water as a new reliable water resource.

The cost of the reused water is subsidized by the Government since, the cost of its production is much higher than the conventional sourced water. This is because of the high quality standards required. All the wastewater plants are built with tertiary treatment and some of them are equipped with advanced technologies such as membranes bioreactors.

In Cyprus, the Sewerage Boards are responsible for the design, construction and operation the plants.

The construction and operation cost of the secondary treatment that is undertaken by the Sewerage Boards, is paid by the users through taxation. Whereas, the construction and operation cost of the tertiary treatment plants is undertaken by the Government for the reasons explained above.

The selling rates of the reused water in Cyprus are as follows:

a/a	TYPE OF USE	**Tertiary Treated Effluent,** Cents of EURO /m^3	**Fresh not filtered water from Government water works,** Cents of EURO /m^3
	Yearly Fee	240,00 per da	240,00 per da
1	For Natural Persons for Agriculture production irrigation divisions for agricultural production	7,00	17,00
2	For Irrigation Water Suppliers	2,00	12,00
3	For Industrial Consumption	17,00	25,00
4	For irrigation of green areas, gardens and fields (municipal and or governmental)	12,00	23,00
5	For irrigation of golf courses	23,00	n.a.
6	For irrigation of private green areas and gardens (hotels and houses)	17,00	36,00
7	For over consumption for agriculture and livestock		45,00
8	For other uses	Increase of the rate by 50%	Increase of the rate by 50%

United Kingdom

Available data is currently insufficient to generate scenario based cost ranges that would provide reasonable indicative capital or operating costs.

Langford cost £13m to build.

The Netherlands

In The Netherlands the reuse of treated waste water is commonly not allowed.