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Water Reuse—Analysis of the Possibility of Using Reclaimed Water Depending on the Quality Class in the European Countries

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Abstract: In 2020, the European Commission (EC) defined a legal requirement for water reuse for agricultural purposes in the European Union (EU). EU Regulation (2020/741) on minimum requirements for water reuse should mobilize member states to implement solutions for the use of reclaimed water. This paper aims to examine the state of implementation of the provisions of this Regulation at the time of its entry into force. Based on desk research, the legal status of water reuse in EU countries, with particular emphasis on the issues of reclaimed water quality and its applications, was analyzed. The state of implementation of solutions regulating water reuse varies significantly across the EU's countries. Central and Eastern European (e.g., Poland, Germany, Latvia, Lithuania, Estonia) countries are in no rush to regulate water reuse in agriculture; some will take advantage of the derogation to gain more time to consider it. Southern countries (e.g., Greece, Italy, France, Spain) are the most advanced and have experience in practical implementations gained before the Regulation was introduced. However, they use different quality control parameters. For now, France, Greece, Portugal, and Spain have fully implemented EC Regulation (2020/741); Belgium, Hungary, and Italy have partially implemented it; Malta has implemented it practically but not formally; and Cyprus has implemented it in distributed regulations. It should be pointed out that the potential for water reuse in the EU is significant, and this process is needed due to climate change consequences for Europe's water resources. Therefore, further initiatives are expected, including the implementation by other countries of the provisions of Regulation (2020/741) in the coming decades.

Keywords: water reuse; circular economy; Regulation 2020/741; water scarcity; irrigation

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1. Introduction

The water and waste water sector is an integral part of the bioeconomy, as the basic factor influencing the development of the bioeconomy is access to renewable natural resources, such as water. Nowadays, globally, a lot of initiatives are being implemented to protect water resources at the local, regional, and international levels [1]. Their beginning can be traced back many years ago when environmental issues began to be included in records regarding the functioning of various sectors of the economy, as well as environmental protection [2]. This applies not only to companies operating in the water and waste water sector [3], but to all sectors of the economy, as well as individual households and agriculture [4].

The newest United Nations Educational, Scientific, and Cultural Organization (UNESCO) report on partnerships and cooperation for water [5] clearly indicates that there is a significant increase in demand for water in the world. It mainly occurs in middle- and low-income countries, especially emerging economies [6]. This trend is influenced by population growth [7], socioeconomic development [8], and changing consumption

patterns [9]. There is also a decrease in renewable water resources per capita observed between 2000 and 2018, mainly in sub-Saharan Africa (41%), Central Asia (30%), Western Asia (29%), and North America (26%), as well as in Europe (3%) [5]. Therefore, there is a justified need to take further measures to protect water resources in every region of the world.

On the global level, the most important initiative to protect water resources was proposed in 2015 by the United Nations (UN), which indicated sustainable development goals (SDGs) in the document 'Transforming our world: Agenda for Sustainable Development—2030' [10]. It defines 17 SDGs, which are indirectly and/or directly related to water protection. The key ones, in the context of the protection of water resources, are SDG6, clean water and sanitation (ensure availability and sustainable management of water and sanitation for all), and SGD14, life below water (conserve and sustainably use the oceans, seas, and marine resources for sustainable development). Currently, on the European level, one of the most important long-term initiatives that indicate the need to protect water resources and manage waste water more sustainably is the idea of a circular economy (CE) [11–13]. It has been indicated by the European Commission (EC) as an economic model for European countries. The institutions of the European Union (EU) define many different proposals, such as legislative changes on water and waste water issues [14], as well as financing investments in this area [13]. CE is defined as an economic model in which raw materials and products are not wasted, and waste—if generated—is managed through the recovery of raw materials [15]. CE is a key block of the European Green Deal (EGD)—the economic development strategy of the European Union until 2050 [16]. Therefore, in the perspective of the next few decades, an intensification of activities to implement water protection measures can be expected.

Particularly noteworthy in sustainable water management is the possibility of water reuse from various waste streams, such as waste water (industrial and municipal), gray water, or rainwater [17,18]. Water reuse is strongly recommended in the industrial sector, agriculture, services, and individual households. In the industrial sector, it concerns the purification of water used in the production process into water of a quality that allows it to be reused in various utility processes—including, for example, cooling, cleaning, or rinsing. Such solutions may bring economic benefits (no need to draw water from the drinking water network) and environmental benefits (no need to draw water from the intake, which means saving natural resources) [19]. The agricultural sector can use reclaimed water based on recovery and use of rainwater and small retention (reservoirs, ponds) and recovery from urban waste water. Irrigation technology and precise watering reduce water losses and are crucial in rationalizing water consumption. The rational use of water in agriculture is primarily economic water management, consisting of appropriate practices that can contribute to significant water savings [20]. Individual households and service sectors can reuse water, e.g., through installations to reuse of gray water (created after washing, washing, bathing) or rainwater. The reclaimed water can be successfully used for flushing the toilet; cleaning floors, devices, or cars; and watering the garden [21]. It should be noted that the reclaimed water must not threaten the environment [22].

According to EC estimations, waste water from urban waste water treatment plants (WWTPs) is a viable option to meet the growing demand for water in Europe. This solution is in line with the CE Action Plan [13] and the new EU Climate Change Adaptation Strategy [23]. The reuse of water from urban WWTPs also helps meet SDG6, which aims to ensure water and sanitation availability and sustainable management worldwide. The availability of water at the outlet of WWTPs estimated for European countries is shown in Figure 1. The potential of treated urban waste water in the EU has been estimated to be six times higher than the current level of reuse. The countries with the highest amount of water that can potentially be recovered from municipal waste water are Italy (9,789,220,099 m^3/year), Spain (7,115,676,493 m^3/year), Germany (6,690,509,040 m^3/year), United Kingdom (5,786,422,089 m^3/year), and France (5,071,827,661 m^3/year) [24]. Currently, reclaimed water is not widely used in European countries. It is becoming increasingly

popular in Mediterranean countries (mainly in Spain, France, Greece, Cyprus, and Malta), where there has been a threat of water shortage in agriculture and drinking water supply for many years [25].

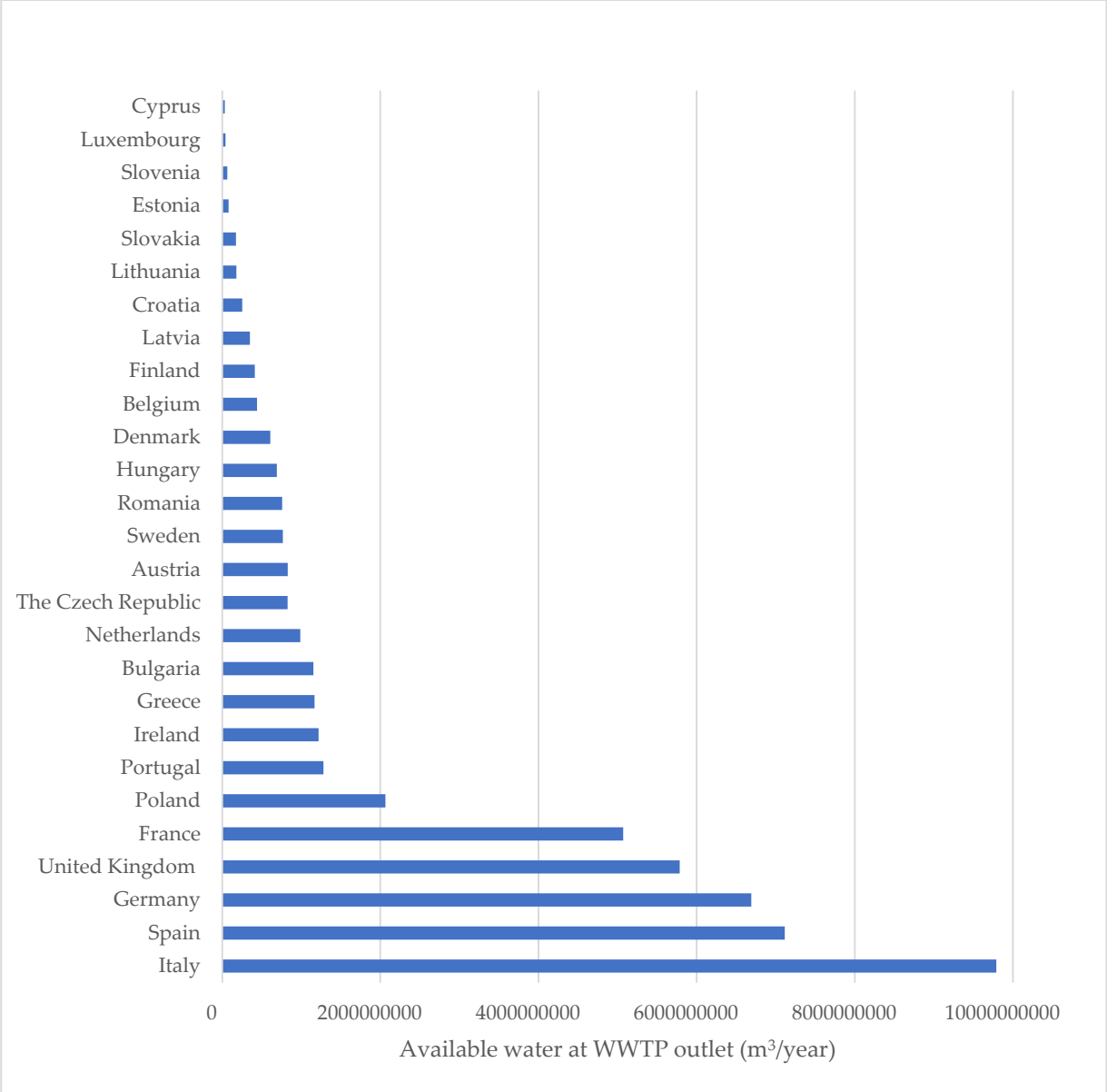

Figure 1. Availability of water at the outlet of the WWTPs estimated for European countries (based on [24]).

According to a report of the European Environment Agency (EEA) [26], data on EU countries are dispersed and difficult to make a detailed inventory. Fragmentary data from 2020 indicate that Cyprus recovers water from more than 90% of its waste water. In Greece, Malta, Portugal, Italy, and Spain, the share of water reuse from urban waste water ranged from 1% to 12% in 2019. Good practices related to water reuse in these countries can be a driving force for introducing regulations adapting national law to EU Regulation 2020/741 on water reuse [14] (hereinafter referred to as the Regulation). Water reclamation and reuse systems are also used locally in other EU countries, e.g., Belgium and Germany in industry, to irrigate urban green areas, and to recharge aquifers. In Sweden, the key driver of water reuse is the protection of coastal water quality and groundwater resources [27].

Until the middle of 2023, all European countries were obliged to present internal proposals for implementing the Regulation [14] to national legal systems. Official data on the details of this process are not publicly available (end of June 2023); however, on 26 June, the European Commission informed about the decisions taken by member states. At the moment, the specific requirements in different countries—those that actively reuse water and have dedicated national documents for this purpose, as well as those that have implemented legal instruments only in selected regions (e.g., Germany)—differ from each other in terms of analyzed parameters, applications, and water classes. The main purpose of the work was to analyze and compare the ways of using water recovered from urban waste water depending on water quality classes. The scope of the article includes an analysis of the legal status of the implementation of the Regulation and a comparison of qualitative criteria at the national and EU levels. The novelty of the result is the comparison of the approaches of all the EU countries and the indication of patterns that can be used by countries with no experience in water recovery and reuse.

2. Materials and Methods

This research was divided into two steps. The first step included a detailed analysis of data sources and documents. Data on the current situation in all EU member states were collected using the desk research method from March to June 2023. It was just before the date of entry into force of the Regulation, which shall be binding in its entirety and directly applicable in all member states starting 26 June 2023. The research procedure was based on [25]. The specific keywords associated with the water reuse area were defined to collect appropriate data sources and documents, which were further analyzed. They included 'water', 'reuse', 'water reuse', 'reclaimed water', 'wastewater', 'waste water', 'sewage', 'municipal waste water', 'waste water treatment', 'treatment plant', 'wastewater treatment plant', 'waste water treatment plant', 'WWTP', 'circular economy', 'CE', 'national law', and 'requirements'. The same names in EU languages were used to search for materials related to local law. For this purpose, we used publicly available IT tools, such as Google Translate, DeepL.com, and GPT chat. Foreign language texts were translated into English. The second step was dedicated to a further analysis of collected data and a comparison of different countries regarding water reuse legislation. The research framework is shown in Figure 2.

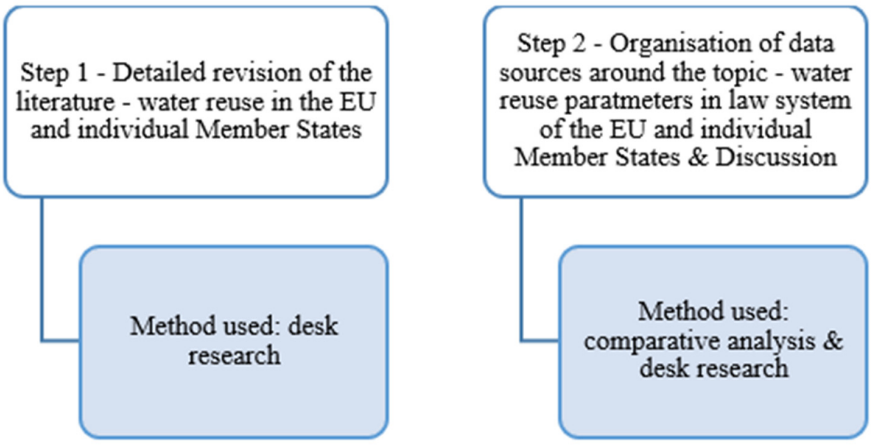

Figure 2. Research design.

The results of this study, followed by the discussion and conclusions, are described in the sections below.

3. Results

This section provides an overview of legal regulations regarding water reuse at the European level, as well as in individual European countries, including an analysis of parameters used in those countries where legislative guidelines for water reuse are in force.

3.1. Water Reuse Regulation at the European Level

Water reuse is an integral element of the CE model; therefore, the Regulation on minimum requirements for water reuse is indicated as one of the implementing acts for the realization of the first CE Action Plan for the EU [12]. The provisions regarding water reuse are obviously continued in the second CE Action Plan for the EU [13], which also emphasizes the possibility of using reclaimed water from urban WWTPs—as a source of not only water but also nutrients, which should be directed to agriculture.

The entire document [14] is divided into 16 articles, preceded by a preamble justifying the need for its implementation. Two annexes define the quality parameters of reclaimed water and measures that have to be taken by water reuse operators. The general idea indicated in the Regulation is to reuse water from an urban waste water treatment plant and direct it to the farmer (end user), who will use it to irrigate plants. The conceptual scheme is presented in Figure 3. The entire cycle is called 'water reuse system', which is defined as the whole infrastructure (including buildings and technical elements necessary for producing, supplying, and using reclaimed water) and elements from the entry point of the urban WWTP to the point where reclaimed water is used for agricultural irrigation, including distribution and storage infrastructure, where relevant.

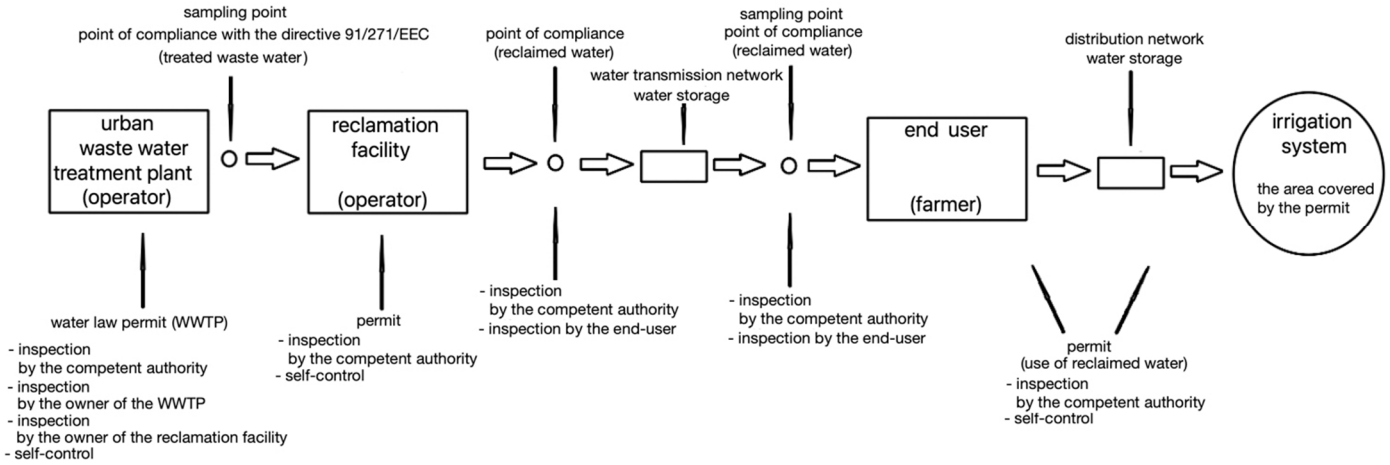

Figure 3. The conceptual scheme of the process of water reuse from municipal waste water, the so-called 'water reuse system' (based on [14]).

The requirements applicable to reclaimed water for agricultural irrigation are categorized into reclaimed water quality classes as follows:

- Class A—all food crops consumed raw where the edible part is in direct contact with reclaimed water and root crops consumed raw—all irrigation methods could be applied here.
- Class B—food crops consumed raw where the edible part is produced aboveground and is not in direct contact with reclaimed water, processed food crops, and nonfood crops, including crops used to feed milk- or meat-producing animals—all irrigation methods could be applied here.
- Class C—food crops consumed raw where the edible part is produced aboveground and is not in direct contact with reclaimed water, processed food crops, and nonfood crops, including crops used to feed milk- or meat-producing animals—drip irrigation or other irrigation method that avoids direct contact with the edible part of the crop could be applied here.
- Class D—industrial, energy, and seeded crops—all irrigation methods could be applied here.

The Regulation is dedicated only to using reclaimed water for agricultural irrigation. However, it also applies to industrial water reuse and so-called 'amenity-related and

environmental purposes' with the provision that it will be used without prejudice to other relevant EU laws in the fields of environment and health. The list of crops that this type of water can feed is indicated in Table 1.

Table 1. Crops that can be irrigated by reclaimed water, according to Regulation 2020/741 on minimum requirements for water reuse (based on [14]).

No.	Crop Type	Description
1	Food crops consumed raw	Crops that are intended for human consumption in a raw or unprocessed state
2	Processed food crops	Crops that are intended for human consumption after a treatment process (i.e., cooked or industrially processed)
3	Nonfood crops	Crops that are not intended for human consumption (e.g., pastures and forage, fiber, ornamental, seed, energy, and turf crops)

It should also be emphasized that EU institutions allow for the extension of the scope of the application of the Regulation, after completing the catalog of applications and defining the appropriate parameters for them.

The specific reclaimed water quality requirements defined for agricultural irrigation are indicated in Table 2. For these parameters, systematic monitoring is obligatory, as well as developing risk management plans and social campaigns to promote water reuse among the public.

Table 2. Water quality requirements defined for agricultural irrigation, according to Regulation 2020/741 on minimum requirements for water reuse (based on [14]).

Reclaimed Water Quality Class	Indicative Technology Target	Quality Requirements				
		E. coli (Number/100 mL)	BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Other
A	Secondary treatment, filtration, and disinfection	≤10	≤10	≤10	≤5	*Legionella* spp.: <1000 cfu/L, where there is a risk of aerosolisation Intestinal nematodes (helminth eggs): ≤1 egg/L for irrigation of pastures or forage
B	Secondary treatment and disinfection	≤100	In accordance with Directive 91/271/EEC (Annex I, Table 1)	In accordance with Directive 91/271/EEC (Annex I, Table 1)	-	
C	Secondary treatment and disinfection	≤1000			-	
D	Secondary treatment, and disinfection	≤10,000			-	

The provisions in the legislation of member states should be adapted to the requirements of the Regulation [14] by mid-2023. This allows for the creation of interdependent management structures between waste water suppliers and users of reclaimed water in the EU regions. As mentioned above, no official information has yet been published on which countries are committed to implementing the Regulation and to what extent. It should also be emphasized that if a member state wishes to use a derogation, it is required to clearly justify it.

3.2. Water Reuse Regulations in European Countries

Even though the countries analyzed below belong to the EU, their legal systems differ depending on the region, problems related to water management, or social acceptance. This section contains a description of the legal systems in member states in the context of water reuse and the implementation of the Regulation.

- Austria

  Austria has no special legislation, and it is not considered a priority to regulate.

- Belgium

  In Flanders, water reuse is widespread on a small and large scale; however, there are many nonagricultural uses, including the direct production of drinking water. For example, the Torreele Water Reuse Scheme, located on the southwest coast of Belgium, produces water from the WWTP Wulpen for artificial aquifer recharge [28]. Belgium does not have any state regulation; however, in September 2022, a regulation amending the water law was published [29]. This decree provides the partial implementation of the Regulation, which means that the first actions have been started.

- Bulgaria

  In 2020, Bulgaria adopted the Strategy and Action Plan for the Transition to a Circular Economy of the Republic of Bulgaria for 2021–2027 [30], which considers water reuse in agriculture and industry. Bulgaria has the potential to reuse reclaimed water due to increasing water scarcity and is willing to fully implement the Regulation [31].

- Croatia

  There is no dedicated legal act despite the water reuse potential.

- Cyprus

  In Cyprus, legislation regulating urban waste water management and containing elements of water reuse is quite dispersed and includes the Environmental Impact Assessment Act [32], Water Pollution Control Law [33], Water Pollution Control (Urban Waste Water Discharge) Regulation [34], Code of Good Agricultural Practice [35], and Regulation on Small Waste Water Treatment Plants < 2000 p.e. [36]. Quality requirements for reclaimed water are defined according to the source of the treated waste water, considering whether they originate in agglomerations with a population equivalent of fewer or more than 2000 (p.e.), in accordance with Regulation No 269/2005 [36]. Moreover, the Code of Good Agricultural Practice [35] provides guidance to ensure the protection of public health and the environment, while the Water Pollution Act [33] and related regulations set legally binding limit values for parameters used in waste water treatment plants. Limit values and quality requirements are defined for more than 20 microbiological and physicochemical parameters. Irrigation with treated waste water is prohibited for leafy vegetables, bulbs, tubers eaten raw, export crops, and ornamental plants.

- Czech Republic

  In the Czech Republic, water reuse is not popular. Legal acts do not regulate the issue of the quality of reclaimed water; however, the State Environmental Policy 2030, approved by the government in 2021, assumes the adaptation of local law to the needs of safe water reuse [37].

- Denmark

  Danish industry and WWTPs have significant experience in internal water reuse. However, reclaimed water is not used in agriculture. The law does not regulate the quality and classes of reclaimed water.

- Estonia

  Water reuse is not a priority in Estonia. The law does not regulate the quality and classes of reclaimed water. Studies and drafting of legislation are at an early stage.

- Finland

The law does not regulate the quality and classes of reclaimed water. Water reuse is not a priority in Finland; however, WWTPs test and implement advanced purification technologies.

- France

In France, the 2010 regulation on the use of water from urban waste water for irrigation of crops or green areas [38] classifies reclaimed water into four categories according to physicochemical properties (suspension and chemical oxygen demand (COD)) and microbiological factors (*Escherichia coli*, fecal enterococci, F-specific RNA bacteriophages, and spores of anaerobic sulfite-reducing bacteria). There are irrigation regulations for agriculture, landscaping, other green spaces, and golf courses. French law allows irrigation of all crops, not only food crops but also ornamental plants, shrubs, wheat, and forests. Two regulations from 2014 [39] and 2016 [40] supplemented the 2010 decree. As a result, irrigation of fresh vegetable crops is subject to stricter standards than, for example, forests.

In 2022, a regulation was issued on the conditions for the reuse of treated waste water [41], which extends the permitting procedure to include the obligation to carry out a risk assessment. The regulation lays down the rules and conditions governing new uses of reclaimed water, other than those already covered by specific regulations.

- Germany

In 2016, the Federal Environment Agency published the study 'Framework conditions for the environmentally friendly use of treated waste water for agricultural irrigation' [42]. Based on the collected data, there was no nationwide need for additional irrigation in Germany. Selected laws and regulations include legally binding minimum requirements for water quality, quantitative limits for the use and discharge of certain substances, and recommendations for flow or concentration assessment. There are many guidelines that can be taken into account when using reclaimed water for agricultural irrigation, e.g., DIN 19650. In February 2022, the federal working group on water issued a report considering further steps possible for the development of German legislation [43].

According to the Federal Environment Agency, the provisions of the regulation are not precise and restrictive enough. Stricter national regulations are needed if Germany wants to introduce water reuse for agricultural irrigation [44]. There is no federal regulation regarding the use and quality of water recovered from waste water.

- Greece

The Greek law distinguishes only two types of irrigation depending on the type of crop, irrigation system, and public access to the irrigated area [45]:

- Limited irrigation, which concerns only crops that are consumed after heat treatment or other treatment or are not intended for human consumption or do not come into direct contact with the soil. Suitable irrigation is adapted to these crops. The sprinkler method is not allowed. Public access to irrigated land is not allowed.
- Irrigation without restrictions applies to all other types of crops, including those whose products are eaten raw. During irrigation, various methods of using reclaimed water are allowed, and no access restrictions are required.

- Hungary

Water reuse is not a priority in Hungary; however, the state decided to implement the Regulation. Therefore, the use of reclaimed water is allowed but not used in agriculture [46]; activities focus only on class D [47]. The normative text for the amendments of Hungarian legal regulations has been completed and published in 2023 [48].

- Ireland

Irish Water has found that the provision of onsite water storage and water reuse can significantly reduce peaks in water demand, reducing pressure on water infrastructure and service levels [49]. However, there is no specific regulation on reclaimed water quality and classes.

- Italy

In Italy, the legal act regulating the reuse of water dates back to 2003 and was introduced in the form of a regulation containing technical standards on the reuse of waste water as an implementation of Article 26 Decree 2 of 11 May 1999. This is the basic legal act that introduced changes to the Act on the Protection of Water Resources. It indicates a list of control parameters for reclaimed water that can be used in agriculture, cities, and industry. National legislation does not differentiate reclaimed water into classes, or, despite the large number of parameters identified (54 parameters), does not consider all the parameters contained in the Regulation, especially the number of microorganisms and pathogens. The 2003 regulation distinguishes three categories of application [50]:

- Irrigation of plants intended for consumption and plants not intended for consumption, green areas, parks, recreation, and sports areas;
- Urban applications;
- Industrial applications excluding the possibility of water in contact with food, pharmaceuticals, and cosmetics.

The Ministry of Environment and Energy Security published on its website a draft decree regulating the practice of water reuse considering the Regulation [51].

- Latvia

Latvia has no dedicated regulation and does not use reclaimed water. Reuse of water from urban waste water is not a priority in legislation.

- Lithuania

There are no water reuse applications in Lithuania. According to [52], it is difficult to expect large-scale recycling and reuse shortly. Water reuse is not a priority.

- Luxembourg

Luxembourg has no dedicated regulation and does not use reclaimed water.

- Malta

Malta has no dedicated legislation on water reuse. However, the Water Services Corporation, the national water and waste water utility, has already adopted the treatment quality standards of the Regulation. An interesting solution is a program called New Water [53]. New Water is highly polished reclaimed water, which can be used for agriculture, industry, landscaping, and other applications. It is available through hydrants, which are accessed by electronic cards.

- Netherlands

Water is not recovered from waste water for agriculture. There are no legal regulations regarding the quality and classes of reclaimed water. However, indirect reuse of treated waste water [54], involving the acquisition of surface water (e.g., in agriculture), which is affected by the treated waste water, is strongly recommended. This phenomenon is evident during low river levels. In the Westland region, research on water reuse was carried out as part of the NextG project [55].

- Poland

In Poland, there is no dedicated law or guidelines for reclaimed water quality. Reclaimed water is not used for agricultural purposes; however, there are many applications in industry. Poland needs more time to implement water reuse from waste water principles in agriculture.

- Portugal

In Portugal, until 2019, treated waste water was used in accordance with the nonbinding national standard NP 4434:2005, and the permitting process was not precise [56]. In August 2019, the Decree of the Council of Ministers regulating the rules for the use of water

from treated sewage was introduced [57]. According to this document, it is possible to use reclaimed water recovered from various polluted waters for nonconsumer purposes, such as irrigation of plants not intended for human consumption, urban uses (landscape, flushing, firefighting, street cleaning, recreational use), or even ecosystem support (maintaining the baseflow of rivers, maintenance of wetlands, recharge of aquifers).

The new regulations provide for producing water for reuse in centralized and decentralized systems, in accordance with the standards of ISO 20760 (ISO 20760-1:2018).

In 2021, another document regulating the use of water from waste water [58] was published to adapt municipal systems to the possibilities of water reuse for the purposes indicated in the 2019 Decree.

According to Decree 119/2019 [57], the division is made into five classes:

A: Irrigation without access restrictions (urban and agricultural uses): plants consumed raw in which the edible part comes into direct contact with water, public gardens, and private gardens.

B: Restricted irrigation (urban and agricultural use): raw crops whose edible part grows aboveground and has no direct contact with water, plants intended for processing and not intended for human consumption, restricted garden, recreational, and sports areas.

C: Restricted irrigation (agricultural use): raw crops whose edible part grows aboveground and has no direct contact with water and plants intended for animal consumption (milk or meat production), except for pigs.

D: Restricted irrigation (agricultural use): production of seeds.

E: Irrigation with limited access (agricultural use): seed production, areas with naturally limited use (e.g., hedgerows and buffer areas, e.g., terraced meadows).

- Romania

Romanian law does not regulate the reclaimed water quality. A feasibility study on water reuse was carried out in Timisoara as part of the NextGen project. Romania is determined to implement the Regulation [59].

- Slovakia

In Slovakia, water reuse for agriculture is not a priority. There is no dedicated law.

- Slovenia

Water scarcity is a fact in Slovenia. According to the project AQUARES [60], the need for water reuse has been noticed; however, there are no regulations or standards. Water reuse is limited to individual cases.

- Spain

Royal Decree 1620/2007 is a legal act establishing a mandatory water reuse system [61]. Moreover, there is a National Water Reuse Plan [62] and more comprehensive guidelines developed by some regions (e.g., Andalusia, Balearic Islands, and Catalonia), which complement legislation at the national level, i.e., Decree 1620/2007. The decree regulates urban uses, including irrigating gardens, cleaning streets, extinguishing fires, and indoor applications, such as flushing toilets. There are many possible routes of irrigation in agriculture and application in aquaculture. Reclaimed water can be used in other economic activities and for environmental purposes, including the recharge of aquifers. Some applications have several subcategories, depending on the degree of contact of the reclaimed water with agricultural products, farmworkers, and bystanders. However, water reuse is not permitted in certain food industry applications, hospitals, swimming pools, and fountains in public places or inside public buildings.

- Sweden

No separate legal regulation sets out the conditions for the reuse of water from waste water. However, other provisions may be relevant, for example, those relating to the working environment, waste management, and by-product management. The Regulation

will be applied as several farmers already use reclaimed water, mainly on two islands in the Baltic Sea.

Table 3 summarizes the state of implementation of Regulation 2020/741 into the local law of all EU member states.

Table 3. Summary of the state of adaptation of Regulation 2020/741.

EU Member State	Status of Implementation of the Regulation into Local Law	Member State Approach
Austria	Not implemented	No applications Not a priority
Belgium	Partially implemented	Selected uses
Bulgaria	Not implemented	Accepted for implementation Selected uses
Croatia	Not implemented	Not a priority
Cyprus	Implemented in distributed regulations	Stricter quality requirements
Czech Republic	Not implemented	No applications Not a priority
Denmark	Not implemented	No decision
Estonia	Not implemented	Accepted for implementation not a priority
Finland	Not implemented	No applications Not a priority
France	Implemented	Wider range of applications
Germany	Not implemented	Accepted for implementation in selected regions
Greece	Implemented	Different division into quality classes
Hungary	Partially implemented	Emphasis on class D Selected uses
Ireland	Not implemented	No decision
Italy	Partially implemented	Wider range of applications Draft amending act available
Latvia	Not implemented	No applications Not a priority
Lithuania	Not implemented	No applications Not a priority
Luxembourg	Not implemented	Accepted for implementation not a priority
Malta	Implemented practically, not formally	Selected uses
Netherlands	not implemented	accepted for implementation selected uses
Poland	Not implemented	No applications Not a priority
Portugal	Implemented	Wider range of applications
Romania	Not implemented	Accepted for implementation
Slovakia	Not implemented	No applications Not a priority
Slovenia	Not implemented	No applications Not a priority
Spain	Implemented	Wider range of applications
Sweden	Not implemented	Accepted for implementation

On 26 June 2023, i.e., on the date of entry into force of the Regulation, the European Commission published information on the status of the implementation of this legal act. On the website of the European Information System WISE [63], a map showing the status as of that day was published (Figure 4).

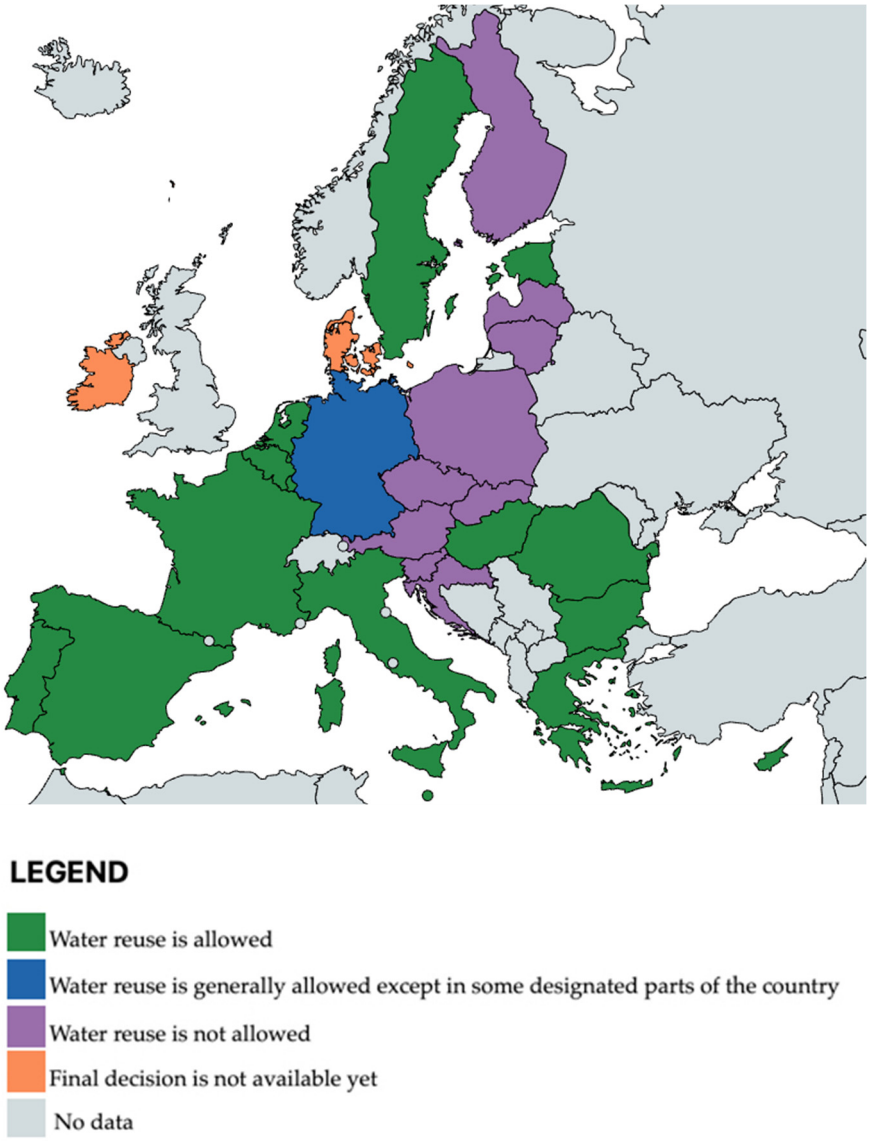

Figure 4. Member states where water reuse for agricultural irrigation is allowed (based on [63]).

3.3. Comparison of Reclaimed Water Parameters in European Countries

The values of individual parameters that are considered in selected EU member states with water reuse laws are different. Their summary is presented in Table 4.

The reclaimed water quality classification criteria should be based on microbiological and physicochemical parameters. Table 5 compares the maximum permissible values of parameters contained in the national requirements for water reuse in selected EU member states and as indicated in the Regulation [14].

Table 4. Parameters used in selected EU member states where legislative guidelines operate.

Parameter	Cyprus	France	Spain	Portugal	Italy	Greece
Turbidity			•	•		•
BOD_5	•			•	•	•
COD		•			•	
TSS	•	•	•	•	•	•
Selected metals			•	•	•	•
Conductivity			•		•	
SAR (sodium adsorption ratio)			•	•	•	
Fluorides				•	•	
Sulfides, sulfites, sulfates					•	
Chlorine and by-products					•	•
Priority substances						•
Other chemical parameters	•	•	•	•	•	
Coliforms	•					•
Escherichia coli		•	•	•	•	•
Eggs of intestinal parasites	•			•		
Fecal enterococci		•				
F-specific RNA bacteriophages		•				
Spores of anaerobic sulfite-reducing bacteria		•				
Intestinal nematode			•			
Legionella			•			
Salmonella			•		•	
Taenia saginata			•			
Taenia solium			•			

Table 5. Parametric values of reclaimed water applicable in selected countries with dedicated legislation.

Parameter	2020/741 [14]	Cyprus	France	Italy	Portugal	Spain
Escherichia coli (cfu/100 mL)	$10–10^4$	$10–10^3$ [1]	$250–10^5$	10 or 100	$10–10^4$	$10^3–10^5$
Other fecal bacteria (cfu/100 mL)	n/a *	n/a	*Enterococci* ≥ log2 to 4	n/a	$250–10^4$	n/a
TSS (mg/L)	10–35	10–45	<15 or [2]	10	10–60	5–35
Turbidity (NTU)	≤5 and no limit	n/a	n/a	n/a	≤5 and no limit	1–15 and no limit
BOD_5 (mg/L)	10–25	10–70	n/a	20	10–40	n/a
COD (mg/L)	n/a	70 or n/a	<60 or [2]	100	n/a	n/a
Total nitrogen	n/a	15	n/a	15	15 or n/a	10 or n/a

[1] Cyprus law applies to coliforms. [2] In accordance with regulations for discharges of treated waste water to the receiver, outside the irrigation period. * n/a—not applicable.

4. Discussion

Water scarcity has increased across the EU in terms of quantity and quality. Therefore, more and more often, the idea of water reuse (for nonpotable purposes) and recycling (for drinking purposes) is discussed in various regions of Europe [15]. The biggest water consumer is agriculture, and reuse for agricultural irrigation is by far the most established end use for reclaimed water, and is seen as a solution to overcome global water stress [64].

According to [65], integrated waste water treatment and reuse systems are typical interactions at city and farm levels, bridging the gap between food and climate sectors. In addition, nutrients and water from reclaimed waste water effluents are valuable and can be reused in urban agriculture as a potential strategy to support local communities.

In the urban economy, it is necessary to shift from safe treatment and disposal of waste water to safe use, including for water reuse. Such a change must also be reflected in legislation [66]. According to Water Reuse Europe Review [67], in 2018 in the EU, a total of 787 reuse schemes distributed across 16 countries were identified. This number is increasing systematically. Such an increase requires systematizing the principles of water reuse and recycling. Before 2020, concrete EU legislation for water reuse was lacking, so member states that wished to implement local solutions developed their own regulations or guidelines (e.g., Cyprus, Portugal, and France). These national guidelines diverged in some important aspects, such as the permitted use of reclaimed water [68]. According to [69], the lack of harmonization of quality requirements has been identified as one of the main barriers to the implementation of water reuse at the EU level and has created a lack of trust in water reuse practices in terms of health and the environment. Agriculture remains the most important stakeholder group. Therefore, in accordance with the principle of subsidiarity, the Regulation focused primarily on agriculture. However, the implementation of the Regulation is progressing slowly. It turns out that in many countries (except Southern Europe), there is no interest in this topic, and the public administration is not prepared to adapt local law to the EU requirements. According to the collected data (Figure 4, Table 3), 9 countries do not allow the use of reclaimed water in agriculture, and 15 have agreed to implement this Regulation, but some of them are still working on the legislative details. On the other hand, it is in this group that the countries whose experience was used to create the Regulation are included. Guidelines for recovering and achieving reclaimed water quality must be based on real parameters, but no universal guidelines exist. The most advanced examples come from North America, Australia, and Israel. In the USA, 11 states have guidelines for water reclamation and reuse [70]. Rules are also being developed in Canada; e.g., British Columbia has issued guidelines for the wide use of reclaimed water, but only at the broad class level [71].

In the EU, water reuse and recycling have different speeds, mainly depending on the climatic zone. There is still no uniform solution. The speed of law adaptation varies greatly. According to the 2018 AQUARES project results, Cyprus, Greece, France, Italy, Portugal, and Spain are the most advanced. However, in most countries, there are no precise guidelines, and water reuse is based on EN or ISO standards and precedents (e.g., Germany, Denmark, Belgium, Malta, Poland) [72].

Article 12 of the 1991 Urban Waste Water Treatment Directive [73] emphasizes that 'treated waste water shall be reused whenever appropriate. Disposal routes shall minimise the adverse effects on the environment'. This opens the way to treat waste water as a raw material. A similar record appeared in the new text of the directive proposed in 2022 by the EC [74]. However, an important breakthrough in regulating the issue of water reuse has become the Regulation. It contains more qualitative details and represents a milestone in developing EU legislation covering the circular economy.

Of course, treated waste water has been used for years in many places, mainly in agriculture, but almost exclusively in southern countries. Among EU member states, Cyprus has the most far-reaching legal principles, where all treatment plants should obtain water that can be used for irrigation in agriculture. However, some countries already have extensive experience in recovering water from urban waste water, using it not only

in agriculture. Such examples can be observed in Poland, where reclaimed water is not used in agriculture at all, but there are cases of its use for cooling power plants, producing artificial snow, or washing streets [75]. Those are important elements of the bioeconomy, which aims to use renewable biological resources (as water) from the land and sea [76].

When analyzing the issue of reclaimed water quality classes, there are differences in the approaches of selected countries to monitoring reclaimed water. For example, France is focusing more on reducing microbiology than on targets. It also imposes legal requirements for distances between irrigated land and sensitive areas, such as bathing areas and drinking water intakes. In many ways, the Regulation is like Spanish legislation. Similar parameters are defined and applied to different classes of water use; for example, for certain uses or irrigation methods, all six parameters set out in [14] are monitored in Spain. However, Spanish legislation is more specific in terms of quality requirements, monitoring, and use of reclaimed water.

Compared with the Regulation, the Cyprus law covers more uses, reclaimed water classes, and control parameters. At the same time, the monitoring system is less rigorous. French legislation is similar in terms of uses, classes, and requirements for monitoring reclaimed water. There is a difference in the monitored parameters. In comparison, the Portuguese framework is more detailed regarding quality parameters.

In all countries with dedicated legislation, there is a distinction between the irrigation of food and that of nonfood crops. They point out the need to consider the issue of water contact with the plant's edible part. Usually, the division into water classes in terms of quality considers whether the plant is edible.

5. Conclusions

Reusing water from waste water becomes a necessity not only in regions with very high water stress, such as Africa or Asia, but also in European countries.

The European Commission has been taking initiatives to protect water resources for many years. One of the last is EU Regulation (2020/741) on minimum requirements for water reuse. It is considered as a good basis for further detailing the law on the safe usage of reclaimed water from urban waste water. However, this Regulation creates some difficulties in its implementation in selected European countries due to differences in climatic conditions or access to water resources.

Countries in Southern Europe have been using reclaimed water for many years; however, their legal requirements differ regarding the quality of reclaimed water. Nevertheless, their experience is crucial to the implementation of this Regulation.

EU Regulation (2020/741) defines water classes depending on the type of crops that are irrigated. Therefore, in national requirements, at least two criteria should be considered:

- Type of plant with particular attention to the contact of the edible part with water;
- Possibility of access to the irrigated area of outsiders depending on the irrigation method.

However, progress in irrigation techniques is an argument for not prejudging the method of irrigation already at the stage of dividing water quality into classes. In addition to the basic monitoring specified in the Regulation, the quality monitoring plan should be adapted to local needs.

In the coming years, a dynamic development of various water reuse methods can be expected, because in mid-2023, many EU countries declared their willingness to take initiatives for water reuse in accordance with this Regulation. All investments related to water reuse—for both irrigation in agriculture and others, such as for irrigation of green areas or in industry—are in line with the concept of circular economy, i.e., the main political direction of the EC.

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