Wastewater Treatment and Water Reuse in Spain. Current Situation and Perspectives

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Abstract: The issues of wastewater treatment and the reuse of water are of great importance, especially in areas where the shortage of conventional resources is a structural problem, as it is in the case of Spain. Wastewater reuse is a valid mechanism to avoid problems derived from droughts and water scarcity. It allows access to water resources in areas with water restrictions and to prevent futures scenarios, due to it being expected that water consumption will double by 2050 over the world. Thus, the likelihood that this unconventional, strategic resource would become scarce is unquestionable, particularly in cases where water planning and exploitation systems prioritize the preservation, protection, and improvement of water quality, as well as the sustainable and efficient use of natural resources. This paper shows how wastewater treatment and reuse are linked, as the reuse of wastewater is associated with a previous regeneration, and both of them are essential tools for maximizing environmental outcomes, as called for in the European Union Directives.

Keywords: wastewater treatment; reclaimed waters; water economic analysis; agricultural supply; Spain

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1. Introduction

Currently, in the water management global context, where agricultural, urban, and industrial water demands are in continuous increase, mainly due to population growth, socio-economic development, and changing consumption patterns [1–9], the reclaiming of treated wastewaters should be considered as a new source of unconventional resources, whose management must be included in comprehensive planning of water resources, taking into account economic, social, and environmental issues [1,5,10]. In particular, global water demand is expected to continue increasing, with a rate of about 1% per year until 2050, accounting for an enlargement of 20–30% above the current level of water use [6–9]. Thus, water reuse can spread the usages of water already used, increasing the availability of water resources. Consequently, reclaimed water can be used in traditional processes that do not require high quality, releasing volumes of better quality for other and more demanding uses [11–13]. In many countries, environmental limitations, together with several and prolonged droughts (as a result of the climate change effects), have led populations to consider the use of treated waters as an additional water source for uses without drinking water quality requirements [13–16]. However, nowadays, over 2 billion people continue living in countries with high water stress, and about 4 billion people experience severe water scarcity during at least one month of the year [6–8].

Reuse profits are shown mainly in the increase of available resources, taking into account that, compared to other alternative resources, reclaimed water presents important advantages even when, currently, they are still in a growing challenge step at global level [10,17–22]. In particular, they are a stable resource to be conditioned by the supply. In addition, reused wastewaters are cheaper than resources obtained through transfers or desalination, since their production need less energy than the

previous methods of increasing supply [1,10,11]. Current wastewater treatments allow producing water with sufficient quality for most uses. Therefore, there is no need to use water with better quality for irrigation or other activities at an excessive cost [14,23,24]. This allows keeping resources of better quality (potable water) for domestic uses. Likewise, the use of reclaimed waters contributes to reducing overexploitation of aquifers, with marine intrusion problems often being especially important in semiarid and densely populated coastal areas [2,3,24–26]. In several cases over the world, after proper treatment, reclaimed waters have been used to provide ecological flows or environmental volumes satisfying, accordingly, numerous requirements fixed by related normatives [14,27–29]. A good example is recognized in the *Pinedo* wastewater plant (Valencia, south-east of Spain) where 78 hm^3/year are reclaimed and used in irrigation crops alongside the environmental restoration of the *Albufera* natural park [24]. These types of waters can also be recovered in industrial or recreational uses. At the same time, the use of reclaimed waters in agriculture decreases fertiliser consumption due to the fact that nutrients involved in these waters can be leveraged by the terrain and, consequently, general improvements of crops production are identified [8,14,15,26]. It also provides alternatives to the discharge of treated wastewaters in areas where dumping is difficult, such as, for instance, spaces included in the public domain. Thus, the reuse can contribute to the purification of these waters when they are discharged in green filters since it removes substances that are difficult to biodegrade [12,26,30]. In addition, the treatments for wastewater recovery increase the sanitary guarantee in areas where wastewater, with lower treatment for the irrigation, was already being used [1,8,13,23,29].

Related to the above mentioned advantages there are numerous indirect benefits of wastewater reuse such as the activity demand in the construction sector and the creation of employment associated with the installation of infrastructures and agriculture maintenance alongside their environmental, social, and patrimonial values. To sum up, reclaimed waters makes the purification processes profitable providing technology and a leading position in the rational management of available water resources [18,20,24,30].

Despite the developed technology and the demonstrated profits of wastewater reuse, currently there is no an international normative in this sense [23,31–35]. Reference recommendations at a worldwide level, and in particular to agricultural use, were provided by the World Health Organization (WHO), published in 1989 with subsequent reviews and extensions [23,33]. In synthesis, this standard involves basic treatments of purification and good practices according with different levels of protection to avoid sanitary problems. Other reference regulations in the development of the normative framework in countries where this practice is carried out were the recommendations given by the United States Environmental Agency [36] and certain public policies conducted by the State of California. They fixed indicators and maximum values where the reclaim treatments, and therefore the quality of the effluent, are subjected to their final use.

2. Study Area and Methods

The present work was focused in Spain. This country shows several differences with regard to the water inputs and water demands distribution from the northwest to the south-east ([2,5,37]; Figure 1). Water inputs are composed by natural sources (surface and groundwater resources) together with non-conventional sources (interbasin transfers, desalination, and wastewater reuse). Surface and groundwater resources closely depend on (i) rainfall amounts which vary between 1000 mm/year and 1500 mm/year in the northwest, whereas values among 300 mm/year and 400 mm/year are recognized in the south-east; (ii) evaporation and evapotranspiration losses which reach their highest rates in the south-east of this country (an average real evapotranspiration of 335 mm/year is registered in the Segura River basin district [38–40]). As a result, the south-east of Spain depicts low levels of natural available water (total runoff in Figure 1a).

In Spain, the most relevant water demands are involved by agricultural, urban and industrial requirements ([41,42]; Figure 1b). In south-eastern Spain, as a consequence of proper climate features and the growth of densely populated urban areas, agricultural, urban and industrial water demands

have exceeded greatly the natural available water inputs ([1,17,26]; Figure 1). Therefore, during the last decades, numerous efforts, through interbasin transfers, desalination and wastewater reuse, were carried out in order to correct the identified negative balance. This particular situation has resulted in, currently, south-east of Spain depicting one of the highest desalinated and wastewater reused rates in the world in terms of production (m^3/day), alongside the developed technology and energy consumption (kW-h/m^3) as can be found in [15,26,43].
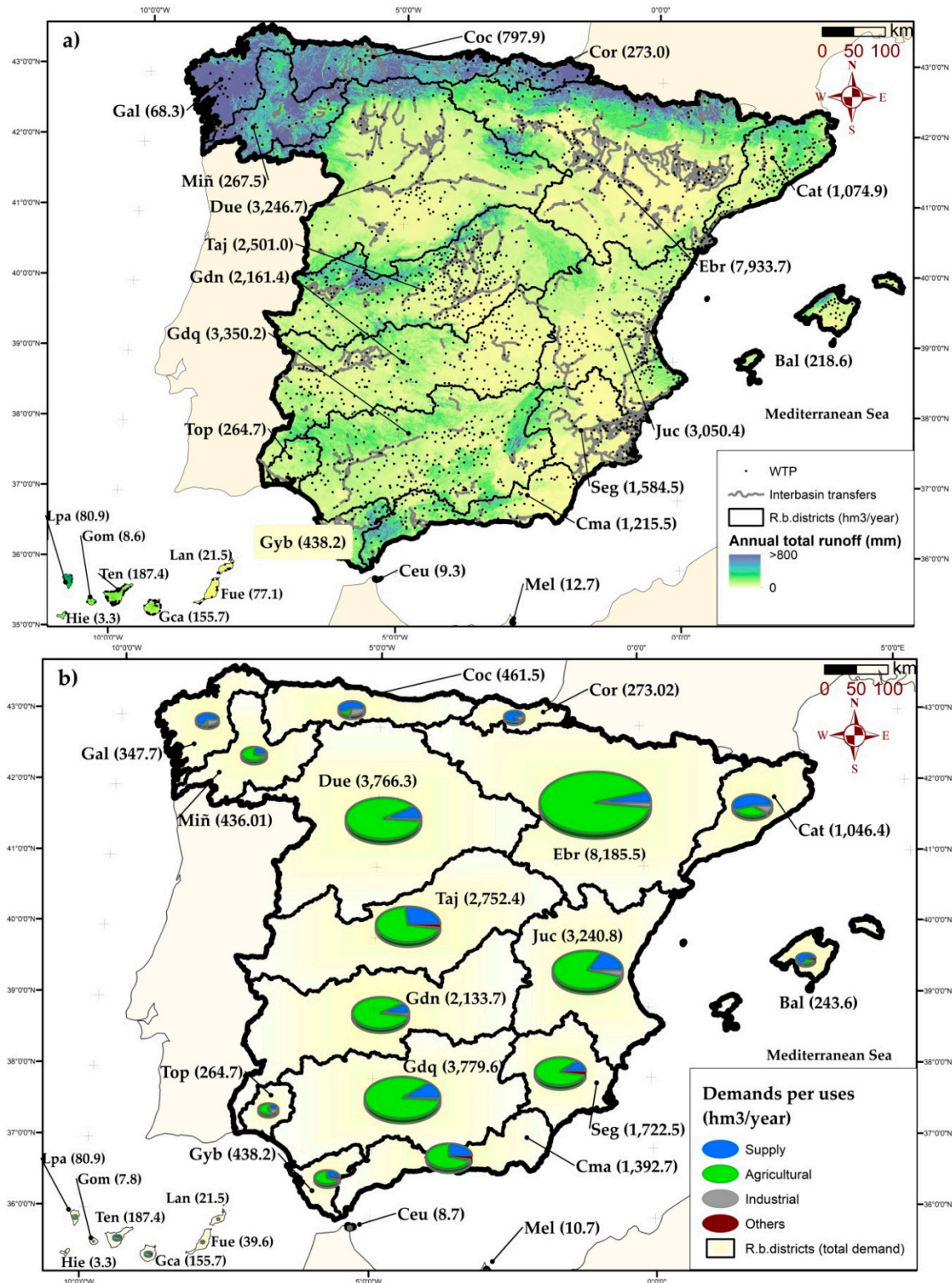
Figure 1. (**a**) Total water inputs in Spain per river basin district (hm^3/year) coming from the total runoff (mm/year), interbasin transfers, reclaimed water from wastewater treatments plants (WTP) and desalinations plants (not showed in the picture); (**b**) Total water demands in Spain per river basin district (hm^3/year) showing their relative percentage based on main uses (supply, agricultural, industrial, and others). Reference year: 2017. (List of the Spanish river basin districts, showed in Figure 1, and their acronyms: *Miño-Sil* (Miñ); *Galicia-Costa* (Gal); *Cantábrico-Occidental* (Coc); *Cantábrico Oriental* (Cor); *Duero* (Due); *Ebro* (Ebr); *Cuencas Internas de Cataluña* (Cat); *Tajo* (Taj); *Guadiana* (Gdn); *Júcar* (Juc); *Segura* (Seg); *Islas Baleares* (Bal); *Guadalquivir* (Gdq); *Cuencas Mediterráneas Andaluzas* (Cma); *Guadalete y Barbate* (Gyb); *Tinto, Odiel y Piedras* (Top); *Ceuta* (Ceu); *Melilla* (Mel); *La Palma* (Lpa); *Tenerife* (Ten); *Lanzarote* (Lan); *Fuerteventura* (Fue); *Gran Canaria* (Gca); *La Gomera* (Gom); and *El Hierro* (Hie)) Source: own elaboration based on [17,39,44,45].

Figure 1 shows the above mentioned water balance, in Spain, among water inputs (Figure 1a) and water demands (Figure 1b) in 2017. It should be noted the water shortage located in South-East Spain despite the resources provided by numerous interbasin transfers beside wastewater reuse and desalination. For instance, the *Segura* and the *Júcar* river basin districts each presented water scarcity close to 200 hm^3 considering their water inputs (1584.5 hm^3 and 3050.4 hm^3) together with their total water demands (1722.5 hm^3 and 3240.8 hm^3 respectively).

Likewise, this study was performed using information and collecting data from several sources which are widely cited in the text. To sum up, these sources can be classified as follows: (i) international and Spanish research manuscripts; (ii) public and private Spanish technical reports from national and local authorities; and (iii) public and private numerical data from the above mentioned authorities together with private companies. These numerical series of data were treated and compiled in [46] and showed in the present manuscript through GIS-based tools [47].

3. Situation of Wastewater Treatment and Water Reuse in Spain

3.1. General Overview

European environmental policy presents among its fundamental principles the conservation, protection, and improvement of water quality, as well as the prudent and rational use of natural resources (water bodies, aquatic ecosystems, etc. [18,48,49]). In order to achieve these objectives, different strategies have been followed the during last decades, ranging from water resources protection based on water uses (quality objectives), to the discharges control through emission standards [23,24,27].

The above mentioned principles were incorporated into the normatives of the European Members States. In the case of Spain, with the Water Law, approved in 1985, a new strategy was initiated regarding the pollution control due to numerous stipulations, that changed traditional approach of discharges, that were considered. The most relevant aspects of this new strategy were (i) "All discharges that can generate pollution require authorization". In practice, this was translated into the requirement to achieve corrective measures to minimize their impact on the environment; (ii) Discharges will be fixed according to their typology and polluting features; (iii) Failure to comply with the limits imposed in the authorization would entail a disciplinary action for damages to the public hydraulic domain. Despite this regulation, in order to apply the mentioned requirements (such as discharge authorizations) in practice, the Hydrological Basin Plans (PHC following their acronym in Spanish) had to be approved because they would establish the "basic features of water quality and the management of wastewater discharges according to their uses" [30,35,50].

The new approach incorporated in the Water Law was soon changed when Spain joined the European Economic Community (EEC), in 1986, and had to comply with the European normatives regarding water quality. Firstly, Spain had to incorporated directives with quality objectives (bathrooms, fish life, pre-drinking, etc.), and next directives of emission standards whose main exponent was the Directive 91/271/EEC concerning urban waste-water treatment [20,26,34,51].

3.2. The National Plan of Sanitation and Water Treatment

In Spain, large-scale purification began with the National Plan of Sanitation and Water Treatment (1995–2005, PNSD), whose main objective was to abide by the Directive 91/271/EEC. Following this normative, the PNSD established the quality of treated wastewaters in accordance with the spill area. Likewise, the PNSD was designed to coordinate actions of public administrations in this matter, due to it presenting autonomous competence. During its implementation period, the total volume of treated wastewaters in Spain changed from 0.13 m^3/inhabitant/day in 1996 to 0.31 m^3/inhabitant/day in 2006. Recent data, published in 2011, quantified the total volume of treated wastewaters in 13.5 hm^3/day throughout the national territory, whose main production is located in the Autonomous Communities of *Andalucía*, *Cataluña*, *Madrid*, *Valencia* and *Murcia* [52–54]. Further, in 2018, Spain was classified as the country with the highest rates of wastewater reuse from the European Union and it belongs to the top ten worldwide [5,15,55].

In 2006, 76% of the total wastewater treatment plants (WTP) in Spain reached requirements fixed by the Directive 91/271/EEC, with an additional 13% of ongoing treatments and 11% of not conforming cases (due to inadequate or lacking treatment). During the 1995–2010 period, Spain only purified 84% of its total wastewater; and although the equivalent not conforming population decreased greatly, reaching a total of 10,909,722 equivalent inhabitants (16%) in 2010, the accomplished effort has not been sufficient and Spain did not fulfil objectives set by the European Union through the Directive 91/271/EEC [10,35,56]. Figure 2 depicts the Spanish evolution of the compliance degree or acceptance with the purification European regulation. It is evident that remarkable progress has been achieved in Spain as a consequence of the PNSD application.

Figure 2. Compliance degree of Spain with the Directive 91/271/EEC (1995–2010 period). Source: own elaboration based on [24,57].

According to the Spanish Ministry [56], in 2010, the Autonomous Communities of *Madrid*, *Comunidad Foral de Navarra*, *Región de Murcia*, *La Rioja* and the autonomous cities of *Ceuta* and *Melilla* depicted the highest compliance degree of Spain with the Directive 91/271/EEC (showing a compliance degree of 100%). However, *Canarias*, with only 52%, was the region with the lowest compliance percentage in Spain (Table 1). Regarding Spanish River Basin districts, *Tajo*, *Guadiana* and *Guadalquivir* depicted, in 2011, the worst levels of water quality. Meanwhile *Miño-Sil*, *Ebro*, *Galicia Costa*, Western and Eastern *Cantábrico* and *Júcar* were the River Basin districts where all the monitoring stations registered values with low pollution [23,34,56].

Table 1. Compliance degree of Spanish Autonomous Communities with the Directive 91/271/EEC. Reference year: 2010. Source: own elaboration based on [51,56].

A. Communities [1]	Compliance Percentage (%)	A. Communities [1]	Compliance Percentage (%)
Andalucía	73	*Comunidad Foral de Navarra*	100
Aragón	88	*Comunidad Valenciana*	90
Canarias	52	*Extremadura*	63
Cantabria	98	*Galicia*	64
Castilla y León	86	*Islas Baleares*	92
Castilla La Mancha	78	*La Rioja*	100
Cataluña	86	*País Vasco*	75
Ciudad Autónoma de Ceuta	100	*Principado de Asturias*	93
Ciudad Autónoma de Melilla	100	*Región de Murcia*	100
Madrid	100		

[1] Autonomous Communities.

The PNSD considered investments with an approximate value of 11.4 € billion, according to provided data by the Autonomous Communities in 1995. This investment aimed to finance the total needs for sanitation and purification in Spain, through the three administrations with power (state, autonomous and local). The Plan assigned, from the contribution of the General State Administration (AGE following its acronym in Spanish) for each Autonomous Community, 25% of the total investment which was required in actions classified as general interest. Therefore, the remaining amount (75%) had to be financed by the Autonomous Communities before December of 2005 [26,50,56]. A relevant element was to ensure the proper installations management (operation and maintenance of the purification systems) to avoid their failure once these plants were built. Thus, AGE recommended to the Autonomous Communities the creation of supra-municipal management entities which could keep the mentioned installations operatives, directly or through specialized companies. In addition, this entailed the collection of a sanitation tax in order to cover operating costs, installations financing that must be assumed by the Autonomous Communities in the PNSD framework, etc. In particular, several Autonomous Communities, due to the problems related with the management of numerous wastewater plants, created entities in this sense such as ESAMUR in *Murcia*, EPSAR in *Valencia*, *ACA* in *Cataluña*, the *Canal de Isabel II* in *Madrid*, NILSA in *Navarra*, and others in the Balearic Islands, *Rioja*, *Galicia*, *Aragón* and the *Basque Country*. To sum up, the PNSD has been essential in the development of the Spanish wastewater treatment, because of it has allowed, since its approval in 1995 until the year fixed in the Directive (2005), the construction of around 700 water treatment plants, which has raised the coverage level above 80% and has improved water quality of the Spanish rivers and the coast. According with information from 2013, Spain presents a suitable compliance degree with the Directive 91/271/EEC estimated in about 84% (57,402,876 equivalent inhabitants) and only 16% (11,129,112 equivalent inhabitants) which do not satisfy requirements fixed by the above mentioned Directive [35,58].

3.3. The National Water Quality Plan: Sanitation and Water Treatment

In 2007, the National Water Quality Plan: Sanitation and Water Treatment 2007–2015 (PNCA) was approved. Its main objective was achieving the total compliance with the Directive 91/271/EEC and the Water Framework Directive (WFD), as well as meeting future sanitation and purification needs [27,48,51]. The total budget allocated for this programme was 19,645 M€, which was distributed in different actions (Table 2 [59]).

Table 2. Planned actions, and their economic valuation, in the National Water Quality Plan: Sanitation and Water Treatment 2007–2015 (PNCA). Source: [59].

	Budget (€)	Percentage (%)
Actions declared of General Interest (involves actions of River Basin districts and State Societies)	1114	5.7
Actions without WTP or with WTP not in accordance	2903	14.8
Actions to recently declared Sensitive areas	4782	24.3
Actions to cover future needs	5620	28.6
Actions to achieve objectives of the WFD	1938	9.9
Actions in sanitation (without purification)	2741	14.0
Actions to promote R+D+I in sanitation and purification	547	2.8
Total	19,645	100.0

Likewise, from the total estimated investment, the Ministry of the Environment undertook to contribute 6233 M€, whereof 3046 M€ came from the first Sanitation Plan, 1777 M€ were associated with new intervention commitments and, finally, 1430 M€ were of recoverable financing in 45 years through the State Societies. However, the implementation of most investments have been avoided due to the economic crisis that Spain has been experiencing since 2008. In particular, the Spanish Ministry has reduced the urgent investment needs until 2020 to almost half, setting them in 10,000 M€. According to the report of Price Water House Coopers (2014) about water management in Spain, during the period 2013–2021, the investment needs of the water sector would amount to 15,700 M€, of which 13,700 M€ would be dedicated to sanitation, sewerage, and purification [30,33,60].

Basic objectives of the PNCA were as follows: (i) Define and ensure environmental stream flows; (ii) Protect biodiversity and the hydraulic and maritime-terrestrial public domains; (iii) Manage terrestrial water and maritime public domains to ensure the quality and good status of surface, groundwater, transition, and coastal water bodies; (iv) Ensure supply to populations; (v) Encourage public participation and ensure an honest water management; (vi) Enhance organisation, cooperation, and inter-administrative coordination to improve provision and levels of services to the population; (vii) Protect the rights of present and future generations to water with high quality and the ecosystems conservation alongside the rich Spanish natural heritage [58,59].

The PNCA fixed that around 1200 hm^3/year, 34% of the total wastewater volume that could be treated in 2015 (approximately 3500 hm^3), would be adequately generated and be potentially available for reuse. Regarding the uses of treated wastewater, in 2007, agricultural use involved 75%, recreational uses and golf courses took 12%, 6% went to urban services, 4% to ecological uses and aquifer recharge, and around 3% to industrial use [29,35,59].

In 2012, Spain depicted a level of purification comparable to the rest of European Union countries, showing a medium degree in the installed conventional purification systems. However, a lower development level related with sensitive areas alongside small and medium agglomerations was recognized in Spain. According with the last report submitted to Europe, in 2013, Spain complies with the Directive 91/271/EEC by 84%. Nevertheless, regarding discharges in sensitive areas with nitrogen and phosphorus removal (article 5 of the assessed Directive) Spain complies only between 40% and 60%. In particular, approximately 700 urban agglomerations present breach proceedings and another 200 are identified as potential offenders. Likewise, despite the European Commission recognizing the "solution of some problems" identified in numerous water treatment systems of Spain, it notes that this country remains "lagging behind" in the implementation of common regulations, especially in the above mentioned sensitive zones due to requirements fixed, by European laws, in these areas are greater as a result of their ecological and ecosystems values. In particular, 27.2% of the Spanish territory is occupied by these spaces (besides involved in the Natura 2000 network), which has caused an increase in the purification needs of around 200 populations with an associated cost of more than 2200 M€ [30,33,34,51].

In November 2014, the European Commission again denounced Spain to the European Union Court of Justice (EUCJ) because this country (i) had not ensured the "correct treatment" of urban wastewaters in several municipalities of *Galicia* and *Cataluña*; (ii) had submitted "incomplete" information or had not announced optimal levels in populations of *Andalucía* and *Cataluña*. In 2015, the proceedings against Spain for incorrect purification concerned 800 population centres throughout the country. In April 2015, the EUCJ sentenced Spain for had discharged non-treated wastewaters from 38 urban areas of more than 15,000 inhabitants. This uncontrolled dumping was a risk that violated European Union laws of health and environment, which have been in force since 2000. The failure to comply was particularly relevant in *Andalucía*, where 13 urban areas discharged wastewaters directly into the sea and the absence of sewage treatment plants caused pollution problems by faecal waters in sensitive areas such as the *Doñana* National Park; in *Galicia*, nine cities failed to comply with the European fixed standards (including *Vigo* and *Santiago*) and the waste dumped into the sea forced closure, during certain years, of economic activities traditionally accomplished in these estuaries (fishing, shellfishing, etc.). Likewise, *Comunidad Valenciana* depicted six spaces penalized by the EUCJ; *Canarias* presented four zones; *Cataluña* two; *Asturias* two; and finally *País Vasco* one [10,11,24,35]. Similar issues and problems are recognized in the rest of European country members. Therefore, it is noteworthy that the water sector is the source of most infractions to the European environmental legislation, producing several related costs [61,62].

3.4. The Plan of Measures for Growth, Competitiveness and Efficiency

As a consequence of the above mentioned fines that Spain suffered throughout several years, in 2014, the Spanish Plan of Measures for Growth, Competitiveness and Efficiency (CRECE Plan) was approved with a principal objective: 2020. The plan was based on the partnership between public and private initiatives, and envisaged several investment mobilisations with European funding estimated in 1000 M€. These grants were assigned to the implementation of purification infrastructures necessary to comply with Community requirements. The aim of this plan was to invest in 400 water treatment plants in order to improve water quality of rivers by purifying water from city sanitation networks [24,34]. Thus, Spain is expected to satisfy environmental objectives fixed by the Water Framework Directive in relation with the good status of surface water bodies:

- In 2016, 64% of surface water bodies had to reach the good status.
- In 2021, 74% of surface water bodies will have to achieve the good status.
- In 2027, 93% of surface water bodies will have to achieve the good status [27,60].

In order to resolve Spanish infringement proceedings, initiated by the European authorities, the Spanish Ministry (MAGRAMA) prioritized the execution of different actions. Therefore, cases which already have a judgment were involved in a cluster with the highest priority (P.1 and P.2). Cases which depict a reasoned verdict were included in a third group (P.3). Nevertheless, the last three categories (P.4, P.5 and P.6) collected the rest of actions without infringement proceedings, but which could be considered as potential breaches, or actions involved in the Hydrological Management Plan of Measures to the date 2027 [33,58,60]. Actions planned to resolve the most important breaches (maximum priority: 1, 2 and 3) and the necessary investments, estimated by the General State Administration (AGE in Spanish) and by the Autonomous Communities, are shown in Table 3.

At the same time, although European funds (*Cohesión* and *Feder*) have been very relevant for the development of the National Purification Plan, the transferred amounts, from Europe to Spain, are insufficient taking into account the great investment needs of the Spanish purification sector. During the period 2014–2020, the European Union will provide to Spain 1700 M€ (700 will be transferred to the AGE and 1000 to the Autonomous Communities) for actions related to environmental conservation and the protection of resource efficiency. In particular, 700 M€ of the State, which will be managed by the MAGRAMA, will invest exclusively in sanitation and purification infrastructures (corrective actions P.1–P.3). However, the 1000 M€ to be managed by the Autonomous Communities must be

used in actions that are not necessarily associated with water resources. Despite this situation, a large proportion of the funding may be invested in sanitation infrastructures. Likewise, a great deficit is recognized in order to finance the remaining actions (with priority: P.4, P.5 and P.6 [23,24,29]).

Table 3. Estimated actions and investments, according to priority, until 2027 to resolve infringement proceedings of Directive 91/271/EEC. Source: own elaboration based on [58,60].

Priority: 1, 2 and 3 (AGE + Autonomous Communities)	AGE		Aut. Communities	
	N° Actions	Investment (M€)	N° Actions	Investment (M€)
Infringement in "Normal Zones" (Populations > 15,000 equivalent inhabitants). Infringement procedure n° 2004/2031.	3	115	2	15
Infringement in "Sensitive Zones" (Populations > 10,000 equivalent inhabitants). Infringement procedure n° 2002/2123.	2	70	13	31
Infringement in "Normal Zones" (2000 < Populations < 15,000 equivalent inhabitants); in "Sensitive Zones" (2000 < Populations <10,000 eq.inhabitants). Infringement procedure n° 2012/2100.	101	212	269	635
Total	106	397	284	681
	Total of Both Administrations			
N° actions	390			
Investment (M€)	1078			

According to [58] and [24], most of Spanish Autonomous Communities depict discharge tax, or similar, with values between 0.4 and 0.5 €/m^3. Certain Autonomous Communities present lower prices of their taxes, or even do not exit, as occurs in *Castilla y León*, *Andalucía*, *Galicia*, and *Canarias*. Regarding the territorial impact of the measures required to comply with the Directive 91/271/EEC, it is minimal in *Aragón* and *Navarra*; between 0.1 and 0.15 €/m^3 in *Murcia*, *La Rioja*, *Asturias*, *Cataluña*, and *Valencia*; among 0.3 €/m^3, or even more, in *Madrid*, *Castilla y León*, *Andalucía*, and *País Vasco*; the rest are placed between 0.1 and 0.3 €/m^3. Thus, the final discharge tax in Spain would be among 0.6 and 0.7 €/m^3 with the exception of *Madrid* and *País Vasco* where it would reach 0.8 €/m^3 [10,15,24,58].

The financing of purification plans is based on the adaptation to European Community regulation, which requires investments to maintain and update existing infrastructures. The Organisation for Economic Co-operation and Development (OECD) and the WFD recommend realizing a strategic financial planning in order to ensure the sustainability and effectiveness of supply and sanitation services. To accomplish this advice, the 3Ts concept was developed. These 3Ts are related with the different alternatives to funding urban water services: tariffs, transfers, and taxes. In Spain, infrastructures implementation is carried out by the Central Government when they are considered as general interest or they affect several Autonomous Communities. However, these infrastructures are accomplished by the Autonomous Communities or municipalities when they are located only in a Community or in municipalities groups [27,33,34].

In relation with the above mentioned National Plan of Sanitation and Water Treatment (1995–2005, PNSD), this plan identified numerous actions for the implementation of European directives. In addition, the plan ensured the correct management of purification systems through the establishment of sanitation taxes. Thus, investor needs were estimated to be around 12,000 M€ and, although in 2005 the budget had not been fully spent, 1000 wastewater treatment plants were built. In particular, 50% of the needed resources were contributions (transfers) from European funds (*Cohesión* and *Feder*), and 25% came from the AGE through bilateral agreements with the Autonomous Communities or taxes [52,53].

Finally, the National Water Quality Plan: Sanitation and Water Treatment 2007–2015 (PNCA) estimated the investment needs in 19,645 M€, if investments in R+D+I were included, from its adoption in 2005 to 2015 in order to deal with the failure to comply with (i) the Directive 91/271/EEC;

(ii) the declaration of sensitive areas; (iii) and the Water Framework Directive. However, due to the economic crisis of Spain, only around 15% of the investments initially planned have been implemented. Subsequently, the MAGRAMA, in 2014, reduced the investment needs to almost half, 10,000 M€ until 2020. Thus, the General State Budgets for 2016 provided several investments to improve water quality through purification and sanitation measures quantified in 179.32 M€. These funds will finance the treatment plants of *Gijón* (*Asturias*), *Nerja* (*Andalucía*), *Ibiza*, and *Santa Eulalia* (*Islas Baleares*), the sanitation plants of the agrarian region of *Hervás* (*Extremadura*) or the general collectors in the city of *Ibiza* (*Islas Baleares*). Likewise, with the Plan CRECE, the treatments plants of *Plasencia* and *Losar de la Vera* (*Extremadura*), *Venta de Baños* (*Castilla y León*), the collectors of *Almendralejo* (*Extremadura*) and the *Mar Menor* (*Murcia*) will be funded. To this must be added the 484 M€ which the State Water Societies will invest in supply and purification actions. In this line of action are integrated the treatment plants of *San Claudio* and *Villapérez* (*Asturias*), *Badajoz* (*Extremadura*), *Orense* (*Galicia*), *Burgos* (*Castilla y León*), and the sanitation of *Vigo* (*Galicia*) and the interceptors of *Ferrol* in *Galicia* [10,24,59].

4. Evolution of the Planned Reuse in Spain

4.1. The Origins of the Planned Wastewater Reuse

The origins of the planned wastewater reuse in Spain are diffused due to, initially, few regulations were recognized and, sometimes, any treatments of wastewaters were accomplished. The first experience took place in *Gran Canaria*, in 1970, through the *Barranco Seco I* wastewater plant (city of *Las Palmas*) using reclaimed water for agricultural irrigation. This practice was later extended to other municipalities of the *Islas Canarias*, *Islas Baleares*, and *Costa Brava*. At the beginning of 1980, plants with settling tanks were built in the *Región* of *Murcia*, in towns such as *Lorquí*, *Ceutí*, *Alguazas*, *San Javier* and *Cartagena*, which used treated water for irrigation. Later, these plants became conventional treatment plants, most with tertiary treatments. Subsequently, effluents of large treatment plants such as *Benidorm*, *Alicante*, and *Castellón* (placed in the *Valencia* Autonomous Community) were also used for agriculture. Likewise, in the nineties the irrigation of golf courses with purified waters began [26,29,32].

It should be noted that the origin of wastewater reuse in the Spanish legal system dates back to the 1985 Water Law. Its article 101 established that "the Government shall fix the basic conditions for the water reuse based on the purification process, its quality and the planned uses". After successive modifications to this law and the approval and later repeal of the National Hydrological Plan (regarding the Ebro interbasin transfer), the Law 11/2005 was the last Spanish law related with wastewater reuse. After, a new regulation was approved under the Royal Decree figure (Royal Decree 1620/2007). The Law 11/2005 indicated that "the Government shall establish the basic conditions for the water reuse, specifying the quality required for treated wastewater based on their expected uses". In addition, this law included that "the holder of the concession or authorisation shall defray the costs necessary to adapt water reuse to the quality requirements in force every moment". In 2009, a preliminary sketch for the National Water Reuse Plan was written, with the limit of the first hydrological planning cycle (2009–2015). Although it was structured to be developed alongside the National Water Quality Plan and the Basin Hydrological Plans, finally it was not approved. Therefore, the Royal Decree 1620/2007 remained the current basic regulation of reclaimed waters in Spain [34,35,63–65].

4.2. The Programme of Actions for Water Management and Water Use

Regarding the National Hydrological Plan (NHP), it was approved, in 2001, within the framework of the law 10/2001, which affirms that "Spain is a country where water is a scarce resource, characterised by several water imbalances due to its irregular distribution". This law tried to establish the basis "for a suitable planning of the Spanish hydraulic policy". The solution of these imbalances, according to the NHP, should consider a coordinated use of all water resources capable of accomplishing objectives of the Spanish water resource management. On this matter, the Law 11/2005, which amends the law 10/2001, established that "interbasin transfers of water could be a solution to the Spanish water

problems. However, their application does not solve the current problems, while there are more practical alternatives linked to the demand management, desalination or the reuse of resources, which would help to alleviate the great demands of water resources recognized in Spain. Thus, overexploitation and pollution of aquifers could be reduced". The law 11/2005 provided a considerable contribution to the wastewater reuse through the national programme "Actions for Water Management and Water Use", known as the WATER programme. In particular, Spain depicted in 2005 more than 2500 WTP treating a volume of wastewaters close to 3375 hm^3/year, which 450 hm^3/year were reused (around 13% of the total treated). This new programme fixed numerous actions to improve Spanish water management, highlighting water reuse and desalination. With both it was planned to increase the water resources, already contributed to by reuse, by 170 hm^3/year [26,63,65]. These actions are shown in Table 4.

Table 4. Reuse actions under the WATER Programme. Source: own elaboration based on [26,63,65].

Actions	Resources Provided (hm^3/year)
Complementary reuse of wastewater in *Campo de Dalías* (*Almería*)	20
Wastewater reuse actions in *Almería*	10
Wastewater reuse in the city of *Málaga*	30
Wastewater reuse in the *Mar Menor* (*Murcia*)	25
Wastewater reuse and complementary works in *Villajoyosa* and other annexed areas (*Alicante*)	10
Wastewater reuse in the WTP of *Novelda* and *Monforte del Cid* (*Alicante*)	5
Wastewater reuse in the WTP of *Sueca* (*Valencia*)	10
Reuse of treated wastewaters in the *Albufera Sur* (*Valencia*)	5
Wastewater reuse in the *Vinalopó-Alacantí* system (*Alicante*)	5
Improvement of wastewater treatment and reuse in the *Plana de Castellón* (*Castellón*)	20
Completion of the wastewater reuse from *Pinedo* (*Valencia*)	30
Total	170

4.3. The National Water Reuse Plan

On the other hand, the National Water Reuse Plan (2010–2015, PNRA) tried to obtain the support and involvement of the Autonomous Communities and the Spanish Basin Organizations for the financing and implementation of infrastructures related with treatment, accumulation, and transport of reclaimed waters. The main objectives of this plan were to (i) achieve the good status established by the WFD to the year 2015; (ii) reach the "zero discharge" in coastal areas; (iii) replace concessions of non-potable water by reclaimed waters, especially in areas located into the continent; (iv) establish a new and dynamic model of financing to help the creation of new wastewater reuse actions; (v) promote the sustainable reuse of reclaimed waters for agricultural, environmental, recreational, industrial, and urban uses, as a viable option regarding the environment, safety, health, economy, and available technology; (vi) estimate the potential for future reuse; (vii) promote good practices of wastewater reuse and inform, raise awareness, etc. of the benefits of reuse these waters [35,66–69].

4.4. Total Volume of Wastewater Reused in Spain

Likewise, according to different references [24,26,29,57], the total volume of treated water which was reused in Spain, in 2006, varied between 368 hm^3/year and 450 hm^3/year (around 10.8% and 13% of the total treated). Currently, the estimated annual volume of wastewater reused in Spain continues showing several differences based on the source of information:

- Since 2008, and according to data collected from the Spanish River Basin districts, the volume of wastewater reused in Spain is 447 hm^3/year [23,70].

- Since 2012, the Spanish Ministry supports an official number of around 408 hm^3/year of wastewater reused in Spain, and 3375 hm^3/year as the total treated water. In addition, this ministry highlights that the total capacity of Spanish wastewater plants can become 30% higher [15,23,67].
- In 2014, the CEDEX organism fixed the reused volume "with concessions" at 796.8 hm^3/year [23,55]. In the same year, the Spanish Statistical Office (INE) quantified the reused water at 531 hm^3/year, while the Spanish Association of water supply and sanitation (AEAS) indicated 373 hm^3/year of reclaimed waters in Spain and 4097 hm^3/year as the total volume of wastewaters treated in Spain [41,42,71,72].
- In 2016, the INE fixed 493 hm^3/year as the annual volume of wastewater reused in Spain, while AEAS quantified this amount in 268 hm^3/year. With regard to the total volume of wastewaters treated in Spain, the INE fixed a total of 4726 hm^3/year and AEAS 3769 hm^3/year [32,41,42,71].

These great changes are due to the lack of data, to the different consideration of reused and reclaimed volumes in certain studies, etc. For instance, in some cases, these variations are consequences of the inclusion, or not, of the ecological flow recovery [23]. In the same way, the total volume of treated wastewater in Spain is directly influenced by the rainfall regime. In 2016, a relevant reduction of the treated volume, with respect to 2014, was registered probably due to the severe drought that Spain suffered that year (2016). In addition, in 2016, water provided to the supply network was 4.080 hm^3 compared to the supplied volume in 2014 (4.231 hm^3). Both circumstances can explain the great reduction of the treated volume in 2016 [23,41,42].

As regards the volume of wastewater reused, taking into account the data of 2014 (373 hm^3), in 2016 a decrease of 28% was depicted (268 hm^3 [42,72]). It is estimated that the current report performed by [42] considered most of Spanish wastewater plants with reuse processes. Thus, the above mentioned reduction (28%) can be justified mainly by the great drought Spain suffered the year of this study (2016 [37,38]).

Regarding the regional distribution of the reused water volumes in the Spanish Autonomous Communities, they are shown in Figure 3. In 2006, the highest flows were used in the Mediterranean arc, *Andalucía*, and the archipelagos of *Baleares* and *Canarias* Islands. In particular, it should be highlighted that the *Valencia* Community, which reused 149 hm^3/year (40.4% of the total treated) and the Region of *Murcia*, which reused 85 hm^3/year (23.0% of the total [24,29,54]). Currently, and according to information of [41,42] to the 2016 year, the *Valencia* and *Murcia* regions continue being the first and the second Spanish Autonomous Communities with the highest rates of wastewater reused. Respectively, they show 131 hm^3/year and 52 hm^3/year (Figure 3). Both reductions, with respect to 2006, are due to the different sources of information and, specially, to the recognized severe drought of 2016 [38,55].

Similar trends are registered in the Spanish River Basin districts following their geographic location. Thus, in 2006, the *Júcar* and the *Segura* River Basins presented the greatest reused rates of Spain showing, respectively, 34% (125.1 hm^3/year) and 28.3% (104.1 hm^3/year) of the total reused volume that year (368 hm^3/year in line with [24,57]), followed by the *Islas Canarias* (9.2%), *Cuencas Internas de Cataluña* (7.5%), *Cuencas Mediterráneas Andaluzas* (7.4%), *Islas Baleares* (6.3%), etc. [57]. Nowadays, and according to the most current information (from 2010 [45]), the *Júcar* and the *Segura* basins continue showing the highest reused rates: 128.4 hm^3/year and 104.8 hm^3/year respectively (Figure 3).

Figure 3 also depicts the location of the most wastewater plants in Spain. It should be highlighted the reuse systems placed in the Mediterranean arc, *Andalucía*, and the archipelagos of *Baleares* and *Canarias* Islands. These areas are relevant due to a combination of high urban, agricultural, and industrial water demands together with scarce water resources. In particular, these spaces present great supply problems due to the depletion and deterioration of traditional water sources, the progressive salinization of the aquifers and the insufficient precipitation regime. Inside the peninsula, Madrid is the region with the highest wastewater reuse rates [1,2,38,57,73].
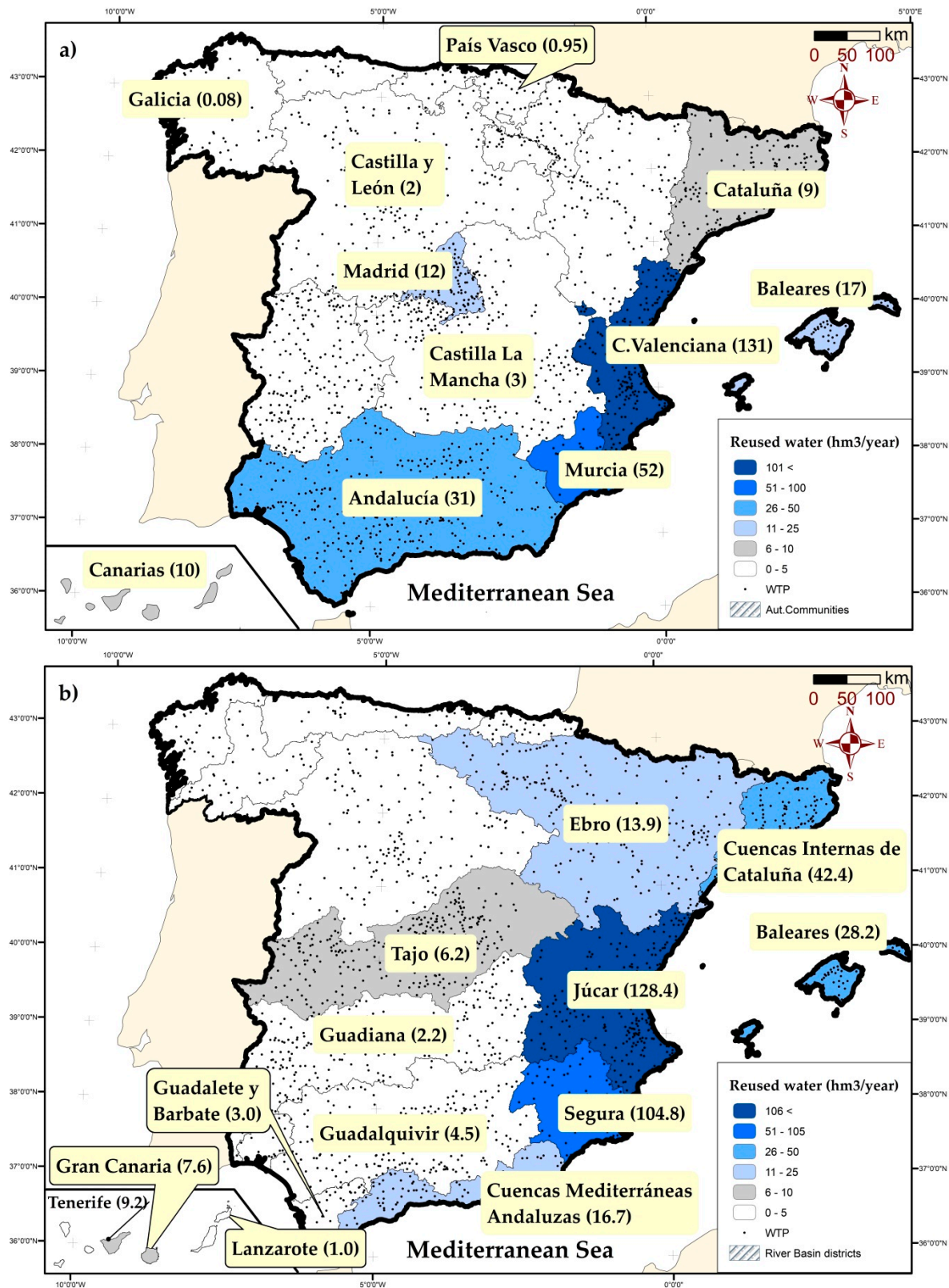
Figure 3. (**a**) Wastewater reused in the Spanish Autonomous Communities (hm^3/year) in 2016; (**b**) Wastewater reused in the Spanish River Basin districts (hm^3/year) in 2010. Both of them (**a**,**b**) depict the location of wastewater plants (reference year: 2015). Source: own elaboration based on [41,42,45,74,75].

5. Uses of Reclaimed Waters in Spain

Currently, reclaimed waters present numerous and varied uses in the world [17,28,31–33,36]. The main uses of reclaimed waters in Spain are shown in Figure 4. Firstly, it should be noted the use in the agricultural sector, with more than 40% of the total reused wastewaters, which are used for the irrigation of pastures, agriculture, woody crops, ornamentals, nurseries and forages, products of human consumption in fresh, among others [41,42,57]. However, according to [23] around the 70% of the total reused in Spain (261.4 hm^3/year) is used in the agricultural irrigation, the main use (end use) of the treated effluents. Generally, most references do not involve, within the agricultural use, irrigated lands which use raw water such as in forest areas. In particular, reclaimed waters, used in the irrigation of forest spaces, must be adapted to the quality limits required by the Royal Decree 1620/2007 [64]. Thus, more than 80% of the total reused in Spain (310 hm^3/year) would reach taking into account volumes to irrigate agricultural and forest areas [23]. Therefore, agricultural is the use that can contribute most to reduce water supply from surface and groundwater resources and, consequently, ensure the natural environment conservation [8,14,32,33,76].

After agricultural use, the irrigation of parks and recreational areas depict the second place in Spain (36% of the total reused, Figure 4). This use can improve the recharge and recovery of local aquifers (for instance to avoid the marine intrusion in coastal urban areas), the restoration and maintenance of wetlands, ponds, the irrigation of green areas, the forestry, the recovery of ecological and recreational flows, the irrigation of golf courses, etc. [13,15,18,28,33]. Golf courses are particularly important in Spain due to an increase of the reclaimed water volume, to supply this use, is expected next years. Nowadays, this country presents around 300 golf courses with a total water demand of 80 hm^3/year. Therefore, most Spanish Autonomous Communities have fixed new normatives in order to ensure the irrigation of these areas with reused wastewaters, such as was imposed in the *Valencia* Community through the Law 9/2006 [77], currently repealed by the law 5/2014 [13,24,33,34,78,79].

Industrial uses present 10% of the total volume reused in Spain (Figure 4). It involves water used in industrial processes to generate new products, cleaning, cooling, condensers, among other applications. Therefore, environmental impacts, derived from industrial activities, and numerous costs can be reduced [41,42,80]. Likewise, a 7% is included under the category of "others" (Figure 4). This cluster contains several uses of reclaimed waters such as activities related with urban and residential purposes (e.g., irrigation of private parks), discharges since sanitary installations, firefighting systems, etc. In particular, during last years relevant increases in the use of reclaimed waters to satisfy urban, recreational and environmental uses are recognized; to the point of some references establish that agricultural together with urban uses reach 83% of the total reclaimed water in Spain [23,41,42]. Finally, a 2% is used in the cleaning of sewage systems and/or street cleaning (Figure 4, [24]).

Regarding the geographic distribution of the reclaimed water use in Spain, it is essential in the Southeast of the country where agriculture involves great volumes of non-conventional resources (wastewater reuse, desalinated water, etc.). For instance, wastewater reused in the *Júcar* and *Segura* river basin districts (Figure 3) constitute the 75.8% of reclaimed waters used in Spain to irrigate agricultural crops. Likewise, in Spain, the reuse of treated waters can cover 5.4% of water demands in relation to the total uses. However, this percentage could reach more than 25% in areas such as the *Canarias* Islands or spreads more than 15% of the total water available for irrigation in the *Murcia* Region (Figure 3, [13,23,32,33]).

With respect to the quality standards of reclaimed waters, they are based on their end use according to the Royal Decree 1620/2007 [64]. This regulation stipulated that "regeneration (reclaim) treatments should be built in those installations that lacked them", and that "the existing regeneration stations had to improve their treatments in order to adapt the quality of the effluents to their final destination (end use)". In Spain, numerous treatment stations reused their effluents only after secondary treatment, due to they did not present regeneration treatment. The main drawback of this situation was the high concentration of suspended solids still existing after secondary (biological) treatment. For this reason, regeneration treatments should present, at least, conventional tertiary treatments

with lamellar settlement and filters of sand, flint, silex, etc. Nevertheless, in the last few years, numerous Spanish WTPs have performed these tertiary treatments together with advanced treatments (coagulation-flocculation processes, filtration, ultraviolet and/or reverse osmosis [4,11,12,23,26,29]).
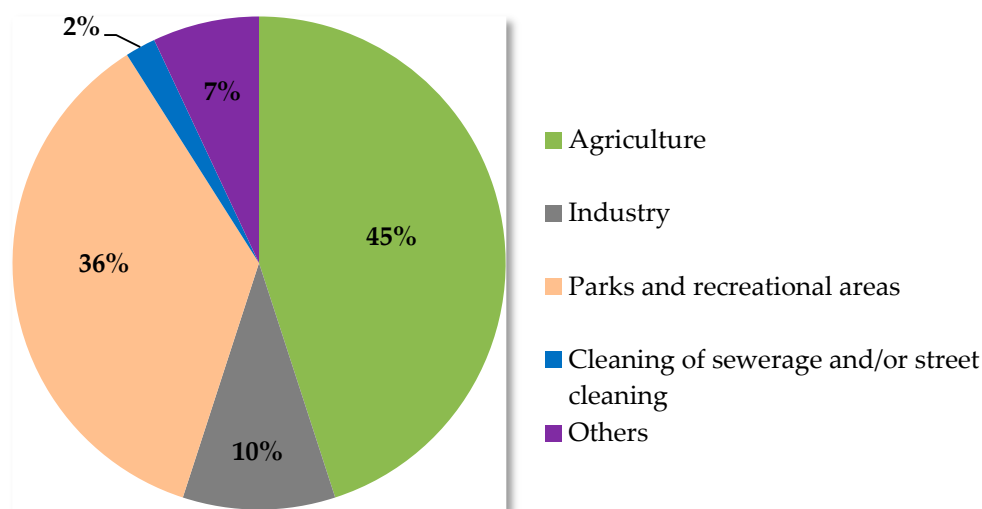
Figure 4. Uses of reclaimed waters in Spain (%) considering a total volume of 268 hm^3/year. Source: elaborated with information from [41,42].

6. Costs of Wastewater Treatment and Reuse

In the framework of the European Union, no specific subsidies are available to promote wastewater reuse [11,35,81]. Existing procedures can be included into two categories: mechanisms to finance initial costs and mechanisms applied to operating costs. However, in Spain there are no reclaimed water markets, being difficult to obtain a price for this product. Therefore, it is assumed that the cost per cubic meter must be equal to the maximum selling price, ensuring that the costs are covered. Thus, in order to promote wastewater reuse, it is essential to create pricing policies that distribute regeneration costs and the management of wastewaters among the total consumption, establishing incentives to ensure that reclaimed waters are used, whenever possible, in all sectors [10,24,34].

The unit cost of water is defined as the ratio between the amounts paid for the water supply plus the amounts paid for sewerage, water treatment and water treatment levies or discharge, and the volume of water recorded and distributed to users. In 2015, the average unit cost of water in Spain was 1.83 €/m^3. The supply reached 1.09 €/m^3, while the sanitation (sewerage, purification, discharge and water treatment levies) was 0.74 €/m^3. The highest values in the unit cost of water were recognized in the *Murcia* region (2.73 €/m^3), *Cataluña* (2.54) and the *Baleares* Islands (2.21). On the contrary, *Castilla y León* (1.00), *La Rioja* (1.06) and *Galicia* (1.19) depicted the lowest costs [24,41,82]. The total unit costs of water, by Autonomous Communities, are shown in Table 5.

Table 5. Unit costs of water (€/m^3) in the Spanish Autonomous Communities (reference year: 2015). Source: own elaboration based on [24,41,82].

	Total	Supply	Sanitation
Andalucía	1.74	1.04	0.7
Aragón	1.46	0.7	0.76
Asturias	1.32	0.68	0.64
Baleares	2.21	1.11	1.1
Canarias	2.03	1.66	0.37
Cantabria	1.56	0.91	0.65
Castilla y León	1.0	0.54	0.46
Castilla-La Mancha	1.28	0.79	0.49
Cataluña	2.54	1.34	1.2
Comunidad Valenciana	2.03	1.23	0.8
Extremadura	1.49	1.04	0.45
Galicia	1.19	0.77	0.42
Madrid	2.02	1.28	0.74
Murcia	2.73	1.86	0.87
Navarra	1.47	0.73	0.74
País Vasco	1.52	0.75	0.77
La Rioja	1.06	0.5	0.56
Ceuta y Melilla	1.95	1.37	0.58
Average unit cost	1.83	1.09	0.74

Regarding the costs of wastewater treatment and reuse, it should be noted they are conditioned by several factors: (i) Firstly, cost amounts depend on the type of waters to be treated, due to their source defines the class and level of pollutants to be removed and the treatment type to be applied; (ii) Likewise, treatment cost is subjected to end use of wastewaters, because depending on the qualities required for these waters certain expensive processes will be applied. There is a huge variability in the costs associated with different treatments, which can also increase as they involve a greater number of processes. For instance, numerous uses, such as wastewater reused in aquifer recharge, in industrial processes, etc., show significant price variations. In this respect, energy costs should be highlighted, since consumption results very different (and, therefore, cost) according to the chosen technique. Thus, a correlation should be considered between the pollution degree of treated water (measured by the ratio among the equivalent inhabitants served and the cubic metres processed) and the energy consumption of the plant [10,11,15,24,29,33].

Generally, the investment costs for a physical-chemical treatment range from 20 to 30 €/m^3/installed day and the operating costs range from 0.02 to 0.03 €/m^3. For sand bed filtration the investment costs fluctuate between 55 and 100 €/m^3/installed day and the operating costs can range between 0.01 and 0.03 €/m^3. Thus, for disinfection with ultraviolet radiation the investment costs can vary among 7.5 and 8.6 €/m^3/installed day and the operating costs between 0.01 and 0.02 €/m^3. The processes of microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO), and reversible electrodialysis (RED) are increasingly incorporated into wastewater treatment, with investment costs varying between 200 and 400 €/m^3/treated day, whereas operating costs range among 0.05 and 0.09 €/m^3. Therefore, the costs of these processes are similar or slightly greater than conventional treatments, depending on the quality of the secondary effluent [12,26,29].

The Case of the Valencia Community

In the particular case of the *Valencia* Community, the region with the greatest rates of wastewater treatment and reuse in Spain, according to private information provided by the EPSAR company in 2015, costs of wastewater treatment reached a total of 0.22 €/m^3, which were distributed as follows: staff costs were 0.088 €/m^3 (40%); energy costs were 0.042 €/m^3 (19%); waste costs 0.035 €/m^3 (16%); maintenance costs 0.026 €/m^3 (12%); reagents costs 0.015 €/m^3 (7%); and finally the cost group named "others" (laboratory equipment, vehicles, fuel, gardening, etc.) was 0.014 €/m^3 (6%). Thus, the

operating costs varied moderately based on the different treatments. These cost reached 0.26 €/m³ with secondary treatment; 0.06 €/m³ with tertiary treatment; and 0.14 €/m³ with advanced treatments. Likewise, distribution cost was 0.1 €/m³ [24,83]. The cost structure of wastewater treatment and reuse in the *Valencia* Community for 2015 is shown in Figure 5.
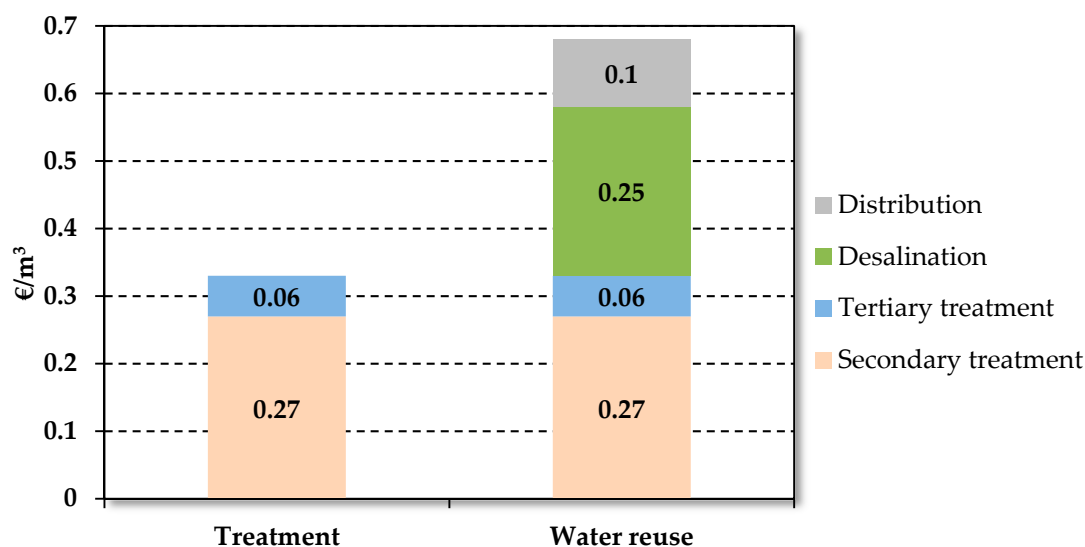
Figure 5. Cost structure of wastewater treatment and reuse in the *Valencia* Community (reference year: 2015). Source: elaborated with information from [83].

7. Conclusions and Future Directions

The inclusion of Spain in the European Economic Community (EEC), in 1986, implied the Spanish adaptation to the European regulation on wastewater treatment, which was more rigorous than the Spanish regulation. Thus, the approval in 1991 of the Directive 91/271/EEC on wastewater treatment obliged installation of collectors to collect wastewater generated by urban agglomerations, and established the necessary treatments according to the location of wastewater discharges. In addition, this law classified spaces into "vulnerable", "less vulnerable", or "normal", with the aim of reducing pollution levels of surface waters.

In 1995, the National Plan of Sanitation and Water Treatment (PNSD) was adopted, which specified several actions in order to achieve European requirements. In particular, this Plan fixed (i) new wastewater treatment plants to be constructed, increased, concluded, or adapted; (ii) the suitable management of water treatment systems through the creation of supramunicipal management bodies and the enactment of sanitation taxes. To sum up, the PNSD was essential in the development of the Spanish wastewater treatment, because it allowed, since its approval in 1995 until the year fixed in the Directive (2005), the construction of around 700 water treatment plants, which raised the coverage level (in relation to the total pollution load showed in equivalent inhabitants) above 80% and improved water quality of the Spanish rivers and the coast.

In 2000, the Water Framework Directive (WFD) came into force, aiming to unify the European Union's actions and achieving the "good state" of water bodies as maximum in 2015. The Spanish response to these new European requirements was the adoption, in 2007, of the National Water Quality Plan: Sanitation and Water Treatment (2007–2015, PNCA), which was designed with the same time horizon as the WFD, and tried to get the full compliance with European requirements.

Likewise, correct water management requires a balance between their economic values and their environmental, social, and cultural values. In this sense, the WFD establishes a new model of water use that can be considered as an environmental or sustainable growth model. Therefore, this model differs from traditional models which aimed to develop economic supply and manage water demands. Thus, models of sustained growth should enhance and stimulate the use of more environmentally and

economically efficient technologies. Under this new concept, water quality is a restriction to economic activity development and, as a result, prices of water resources must be fixed involving opportunity costs, water shortages, and environmental damage. Hence, in order to promote wastewater reuse taking into accounts the increase of water price, it is essential to create pricing policies that distribute regeneration costs and the management of wastewaters among the total consumption, establishing incentives to ensure that reclaimed waters are used, whenever possible, in all sectors.

In recent decades, Spain has failed to meet certain European requirements (Directives) related to water treatment and reuse and, consequently, this country received numerous sanctions from European Union (mentioned throughout this study). Currently, Spain does not comply with Community regulation on urban water treatment. The coverage level is close to 90% of the total, in relation to the pollutant load, but it is especially far from meeting the WFD objectives for water purification in municipalities with more than 10,000 inhabitants. In particular, only 32% of these Spanish municipalities present tertiary treatment systems required by Community regulation. Last 25th of July 2018, European Commission imposed, to Spain, a relevant fine (12 EUR millions) due to certain deficiencies related to the gathering and treatment of urban wastewaters in numerous Spanish urban agglomerations [84].

Despite the above mentioned sanctions that Spain has received from European Union, it should be noted that this country presents one of the greatest rates of wastewater reuse in Europe and globally. According with different sources of information, the annual total volume of wastewaters reused in Spain currently varies between 493 hm^3/year and 268 hm^3/year. Regarding its main uses, around 40–70% of this volume is used in the agricultural sector, followed by 36% used in the irrigation of parks and recreational areas. Industrial uses present 10% and 7% is involved in several uses of reclaimed waters such as activities related with urban and residential purposes, discharges since sanitary installations, etc. Finally, a 2% is used in the cleaning of sewage systems and/or street cleaning.

To sum up, in Spain, there are two aspects to manage in the future: (i) the incorporation of new technologies which depict fewer energy costs, more respect to the environment, less waste, etc.; and (ii) a change in the financing model, with a greater emphasis on sanitation taxes and water tariffs, to ensure compliance with the cost recovery principle.

In this new model, the potential of water reuse is an incontrovertible fact, especially in countries with scarcity problems such as Spain. Thus, its consolidation as an unconventional strategic resource is a challenge that forces all actors with responsibility in this subject to act in a coordinated and absolutely rigorous manner in the planning of future actions. In this sense, it is essential that regional administrations encourage and even oblige to use treated wastewaters whenever possible, mainly in spaces affected by permanent deficit. In particular, the Royal Decree 1620/2007 establishing the legal regime of water reuse in Spain, was an important step in the regulation of wastewater reuse by clarifying the responsibilities of (i) public administrations; (ii) authorized dealers; (iii) end users, etc. In addition, this regulation fixed quality standards for each possible use of these flows. However, in Spain, there is still a mechanism needed to enhance reuse and the alignment of existing installations with the highest quality requirements.

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