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Wastewater Treatment Plants in Mediterranean Spain: An Exploration of Relations between Water Treatments, Water Reuse, and Governance

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Abstract: Wastewater treatment plants (WWTPs) are fundamental to enable the transition towards the principles of a circular economy in water supply. In Mediterranean Spain, an area with recurrent episodes of water stress, treated wastewater may become a critical resource for the future. However, its incorporation into the array of potential water options opens up questions regarding the different qualities obtained with each treatment, the extent of existing water reuse practices, or the governance regime of plants. In this paper, the state of WWTPs in Mediterranean Spain is analyzed, with focus on plant sizes, treatment technologies, water use, and governance regimes. The latter shows a strong presence of private WWTPs and a lesser extent of public–private WWTPs, while the number of public plants is small. Regarding treatment technologies, the most sophisticated systems are found in public–private plants that are also the largest in size. Reclaimed water is very significant for agricultural and golf course irrigation in some areas (Valencia, Murcia, Andalusia), but still relatively incipient for other uses.

Keywords: wastewater; treatments; management; uses of reclaimed water; Mediterranean Spain

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1. Introduction

Wastewater treatment plants (WWTPs) are a fundamental area for implementing the principles of the circular economy in water supply [1]. Recent technological advances involving sophisticated treatments such as reverse osmosis or ultraviolet light, among others, are improving the quality of the final effluents so that these flows can be reused for a variety of purposes [2]. Concepts such as treated wastewater, water reuse, water recycling, and reclaimed water tend to be considered as synonymous, which may lead to confusion [3,4]. For the purposes of this paper, treated wastewater is water the quality of which has been improved in a WWTP, while reclaimed water is treated wastewater put to a specific use [5,6]. In Mediterranean Spain, an area with recurrent episodes of water stress mainly caused by scarcity and pollution, treated wastewater reclaimed for reuse may become a critical resource for the future. In parallel, reclaimed water opens up several questions regarding, among others, the different qualities obtained according to types of treatment, the variety and extent of existing reuse practices, or the governance regime of this resource [7,8].

The paper examines the state of WWTPs in Mediterranean Spain focusing on plant sizes, treatment technologies, and reuse practices. One special point of interest concerns the governance regimes of WWTPs, particularly the type of prevailing management (public, private, and public–private partnerships) and its possible relationships with size, technological capacities of plants and reuse of treated flows. The main objective of the paper is to provide a comprehensive assessment of the status of wastewater treatment in this area and especially of its potential for reuse. Additionally, the paper attempts to examine the governance systems of WWTPs, especially the weight of private ventures in these facilities. In order to accomplish these objectives, the paper uses an exhaustive database compiled by the authors on WWTPs in coastal cities and metropolitan areas of Mediterranean Spain, organized around several headings such as size; ownership and management; treatment systems; and production and destination of the treated water. A list of sources used for the database is included in the additional materials section of the paper.

In the next section we provide an overview of wastewater as a new frontier in water resources development, framed in terms of potentialities and problems. This is followed by a general account of the state of wastewater treatment and water reuse in the European Union and Spain. The methodological section is dedicated to the design of the data base on WWTPs and the sources of information used. In the results section we describe the main technical and managerial characteristics of WWTPs in the study area, as well as the amount and destination of treated wastewater produced in the plants. The discussion section attempts to relate the characteristics of plants to their potential in providing ample and secure resources for future periods of water stress, assessing especially the role of reclaimed water for a variety of uses under a variety of governance regimes (private, public and public–private partnerships). In the conclusions, the main findings of the paper and their relevance for the future of water in Mediterranean Spain are summarized.

1.1. Wastewater: A New Resource Frontier?

Freshwater availability for present and future generations is one of the major challenges faced by human societies in many world regions [9]. Serious warnings have been made regarding the intersection between population, economic growth, water availability and demand, and water pollution [10]. Although irrigation will continue to lead current world water consumption by far, it is expected that the highest increases will come from the rapidly urbanizing developing nations. Contrary to irrigation, where most of the water is lost to evapotranspiration, domestic, industrial, and residential use, returns significant amounts of water to the environment, although in qualities often unfit for ulterior uses. According to Florke et al. [11], domestic and industrial water use multiplied by 4.8 between 1950 and 2010, while population increased 2.7 times. However, barely 12 percent of the 1345 km^3 of water withdrawn in 2010 was consumed, the rest being discharged into the environment. Moreover, between 2000 and 2010, some 70 percent of wastewaters had their origin in the residential sector.

These figures imply that, at least theoretically, a substantial amount of future water needs could be provided by treated wastewater. It does not come as a surprise then that the 2017 World Water Development Report of the United Nations defined wastewater as the “untapped resource”, changing significantly old precepts such as “treat and dispose” with new ones such as “reuse, recycle and recover” [12]. At the policy level, in 2020 the European Union finally agreed upon a regulation which recognized the strategic importance of treated wastewater for member states, although limited its application to agricultural uses [13]. CEOs of water utilities such as AGBAR and NGOs such as the Spanish Foundation for a New Water Culture, critical in the state of water affairs in Spain, both praise wastewater reuse as an example of the application of sustainable principles to water management [14,15]. These supporting views emphasize the potential of treated wastewater to increase the amount of water resources available under the principle of “fit for purpose”; in other words; the possibility of matching specific qualities with specific uses, even uses involving direct contact with the human body and therefore highly demanding in quality terms. In parallel, current advanced wastewater treatments already allow for the production of pre-drinkable effluents reaching quality levels sufficient for most uses at energy costs that are comparatively smaller than those of desalination or long distance water transfers [16].

The possibility of obtaining increasing flows of good quality water in WWTPs corresponds well with the expanding range of water uses found in urban areas, from residential, commercial and industrial to public leisure and environmental amenities. The direct or indirect production of drinking water from reclaimed water is also an option explored and implemented worldwide, from Namibia and Singapore to Orange County in California, as well as in several European cities [17,18]. In Europe, treated wastewater is often the source of irrigation of public parks and gardens in cities. However, water-stressed nations in the developed world have not employed the use of reclaimed water, at least at a large scale, preferring conventional resources or desalinated water to overcome increasing scarcities. To an important extent, the reason for this may lie in the technical and logistical difficulties associated with the development of dual water supply systems for residential, commercial and industrial users.

Treated flows from WWTPs may be also controversial. Health concerns have made the acceptance of treated wastewater for drinking especially difficult, at least, directly. Public acceptance has also proven a hurdle in certain cases especially when reclaimed water is proposed for uses involving close human contact (drinking, bathing, cooking) [19]. Concerns have also arisen regarding the increasing presence of the so called "emerging pollutants" in wastewaters, including microplastics, sometimes hard to detect and remove even with sophisticated treatments [20]. Finally, declining consumptions, partly related to episodes of water stress in certain areas of the developed world, could reduce the amount of wastewater theoretically available for reuse.

1.2. Wastewater Treatment and Reclaimed Water Use in Europe and Spain

The European Directive 91/271/EEC on urban wastewater established the obligation of member states to collect and treat wastewater in urban settlements with a population equivalent of at least 2000 inhabitants, and apply more advanced treatments in urban settlements with populations over 10,000 located in designated sensitive areas [21]. In 2017, about 80 percent of the European population was connected to wastewater treatment facilities and 69 percent enjoyed tertiary treatments including nitrogen and phosphorous removal [22]. However, water reuse barely sums 1.7 billion m^3, less than 5 percent of total wastewater generated and below 1 percent of total water abstraction in the EU [23]. Except for agricultural irrigation in Spain, Italy, and other Mediterranean countries, water reuse in the EU is very small, essentially due to sufficient water availability from conventional sources; high economic costs; and because of the absence of clear health and environmental regulatory standards.

In May 2020, the European Parliament and the Council harmonized minimum requirements for reclaimed water through EU Regulation 2020/741, but only for agricultural irrigation, including risk contingency plans for the protection of human and environmental health. According to the European Commission, the new regulation could increase water reuse to 6.6 billion m^3 per year [13]. Moreover, industrial, amenity and environmental uses could also be authorized depending on the needs of member states. However, the possibility of adding treated wastewater to existing drinking water sources was not mentioned in the European regulation, and national legislation in some countries, such as Spain, explicitly prohibit this use [24]. However, in some countries, projects involving reclaimed water for potable uses exist. The first was the Torreele/St. André plant in Flanders, Belgium, in 2003 supplying some 60,000 people with treated wastewater previously injected into a coastal aquifer [25], followed by the Langford plant in Essex, UK [18]. The years ahead may see an increase in these projects if projections on future water needs, coupled with increasing uncertainty about precipitation, threaten current water supply systems. London, for instance, considers the possibility of using reclaimed water for drinking purposes in the future [18]. Given that, in order to protect the water ecosystems of the continent, the European Water Framework Directive is very vigilant on new water abstractions, new sources will have to be provided and reclaimed water may be one of them.

In Spain, wastewater treatment and reuse are governed by the EU Directive of 1991 on Urban Wastewater Treatment, transposed into Spanish legislation through the Law 11/95, and by the Spanish Royal Decree 1620/2007, on the Legal Status of Wastewater Reuse. In 2017, 97 percent of the Spanish population was connected to a wastewater treatment plant and 69 percent were connected to plants equipped with tertiary treatments. Wastewater treatment capacity attains some 8000 Hm^3 per year, while flows actually treated represent 4800 Hm^3, of which some 385 Hm^3 (8 percent) were reused in 2018 [26]. Spain leads Europe in water reuse. Agricultural irrigation is the destination of 41 percent of treated wastewater, followed by irrigation of golf courses and public parks (31 percent). Hence, irrigation concentrates over 70 percent of water reuse, both for productive (agriculture) and leisure (golf) purposes [27]. Both activities are heavily concentrated in Mediterranean Spain, especially in the autonomous communities (regions) of Murcia and Valencia.

Nevertheless, according to the European Commission, the status of wastewater treatment in Spain is not satisfactory and fines of several million euros have been imposed for not complying with the 1991 Directive on wastewater treatment. Two problems have been identified. First, existing deficiencies in the collection and treatment of urban wastewater with certain parameter values below mandatory requirements, and second, the failure to incorporate tertiary treatments to all towns above 10,000 people. In 2018, a fine of 12 million euros was imposed by the European Court of Justice [28] after the country repeatedly missed warnings to correct these deficiencies.

Given the leading position of Mediterranean Spain in wastewater reuse, not just in the country but in Europe as well, it is important to explore with more detail the technical and managerial characteristics of WWTPs in this area in order to offer precise details of the potentialities and shortcomings of a critical alternative water resource, attempting to find a solution between conventional surface and groundwater on the one hand and desalination on the other. Likewise, the study of wastewater governance, especially the ownership and management of plants, may provide some hints as to the current and future orientation of water policy in a region where the water supply of many cities has been turned over to the private sector during the last few decades.

2. Materials and Methods

The study area is formed by the autonomous communities (regions) of Catalonia (provinces of Barcelona, Girona and Tarragona); Valencia (provinces of Alicante, Castellón and Valencia); Murcia; Andalusia (provinces of Almeria, Granada and Málaga) and the Balearic Islands (Menorca, Mallorca and Ibiza). Of all the WWTPs in this area, we have selected only those located in coastal municipalities or in metropolitan areas including a coastal zone. Furthermore, the analysis only considered WWTPs for which public information is available. This implies leaving out a substantial number of plants belonging to private ventures (such as residential developments, hotels, etc.). In addition, WWTPs lacking sufficiently clear information about the different items analyzed (management type, treatment, etc.) were also excluded. This may affect the total number of WWTPs considered for each item analyzed, which may vary according to the information available.

To characterize WWTPs, a database with 34 items was created. Items were classified in four basic categories: (1) Basic data; (2) Technical profiles of WWTPs; (3) Water reuse, and (4) Miscellaneous (see Table 1).

The main sources of information were the regional water agencies providing a general overview of the WWTPs under their regulatory responsibility. However, not all these agencies offered the same information, or information with the same level of detail. For example, energy consumption was only available for WWTPs in Catalonia and Valencia [29]. Likewise, the information provided on certain treatments (especially tertiary treatments) also differed considerably among regions. Moreover, it was difficult to know the exact number of WWTPs in operation, because there were some private facilities (in hotels, golf courses or residential communities) that could go unaccounted for. Hence other sources of information were used, including companies managing the plants; local, supralocal (consortia) and regional governmental offices, and also the European Environment Agency (EEA) which compiles data obtained from the implementation of the 1991 Urban Wastewater Treatment Directive. In accordance with this Directive, member states must submit annual data on wastewater flows and treatments to verify compliance with the emission control standards. This information has served to contrast and complete the database (see Table 2). Finally, in some cases, academic papers and technical reports, as well as (written) media sources were used (see Appendix A for a complete listing of webpages used).

Table 1. Main characteristics of the database on WWTPs. Source: Authors.

Category	Main Items
Basic data	Name; year of construction and/or expansion; location (municipality, province, region); municipalities served; company in charge of management (public, public–private or private); regional public water organism in charge of supervision.
Technical profile	Designed wastewater flow (m^3/day); designed capacity (in person-equivalent); treatment systems (primary, secondary, and tertiary with a brief description of each one); length of wastewater pipes (km); wastewater parameters (BOD5, COD, Suspension Solids, nitrogen and phosphorous); and energy consumption (MWh/year) when available.
Reclaimed water and reuse	Availability; percentage of water reused; type of reuse (direct or indirect); and destination.
Miscellaneous	Sources of information; missing and/or incomplete data; other remarks.

Table 2. Sources of information for the database on WWTPs in Mediterranean Spain. Source: Authors.

Regional Water Agencies	Agència Catalana de l'Aigua (ACA); Entidad Publica de Saneamiento de Aguas Residuales de la Comunidad Valenciana (EPSAR); Entidad de Saneamiento y Depuración de la Región de Murcia (ESAMUR); Agència Balear de l'Aigua i la Qualitat Ambiental (ABAQUA); and Agencia de Medio Ambiente y Agua de Andalucía.
Water Companies	Private companies (ACCIONA, SOREA, CADAGUA, Hidralia, etc.); Public–Private partnerships (SIMMAR, Empresa Mixta de la Costa Brava, EMATSA, Emanagua); and Public Companies (GALASA, AXARAGUA, EMAYA, Nostraigua).
Public Organisations	City Councils; River basin authorities (Confederaciones Hidrográficas); and other entities (Provincial Councils, Consortia, etc.).
Other Sources	European Environment Agency; academic and technical papers; and local and regional media.

Obtaining the information desired and harmonizing it for comparison purposes proved to be very arduous. Therefore, the database presents some information gaps as well as uncertain values in some cases. The major problems found when compiling information were the number and ownership composition of companies managing WWTPs; the design data of the plant; and the amount and destination of treated wastewater. For 14 plants (in Murcia, Andalusia, and the Balearic Islands) no official information as to the company operating the WWTP was found, or the name provided was doubtful. As for ownership, some companies were jointly owned by a public–private company and by a public company. In this case, the final distribution of ownership reflected the total percentages of the public part and the private part. Data on the year of construction or large rehabilitation of plants was not found in 19 cases. Regarding treatment flows, designed capacity was missing for 43 plants. In these cases, if known, actual capacity was used instead. One major difficulty was the meaning of "recycled" or "reclaimed" water for reuse, which varied in each region.

In 26 cases, sufficiently clear information on this attribute was missing, while for 17 additional plants the recycled flow was unknown. For 7 more, whether or not the water was actually reused could not be determined. Contradictory information, especially about treatment systems, was rather common. In these cases, information provided by the regional water agency was prioritized. If this source was not updated, then data submitted to the EEA received preference. An attempt was made to include the most recent information (2018 and 2019), although for some plants and for some of the attributes the most recent data went back to 2011 or even 2005, especially in the case of information provided by river basin authorities. The database does not include small WWTPs associated with residential areas, especially in the Valencia region, due to size and to the general lack of data. In terms of regional data availability and quality, official sources from Andalusia and the Balearic Islands contained relatively little updated information on treatment systems. For 12 Andalusian WWTPs, it was not possible to confirm whether they were in operation because of scarce and missing information.

The volume and quality of information diverged significantly among regions. Catalonia was the region with the most updated data, whereas Andalusia and the Balearic Islands were the regions with the least information available. Regarding the different items in the database, affected municipalities, ownership and management, and plant capacity were relatively available. On the other hand, more specific parameters such as BOD5 or COD, energy consumption [30], and water reuse were the most difficult to find, at least with recent data.

3. Results

3.1. Location

In total, 294 WWTPs were located for the study area of which 279 were operative as of 2020. Figure 1 shows the year of construction of the plants for the entire area and for the five regions considered. It can be seen how the period with the largest number of new WWTPs was 1991–2000, with more than 47 percent of the total (above 65 percent in Andalusia and the Balearic Islands), coinciding with the 1991 EU Directive. In contrast, the period 2010–2020 with the new plants into operation marks the lowest number, probably because most municipalities were already served, but also because of the economic crisis suffered by Spain during that decade and which left a heavy impact on public investments.

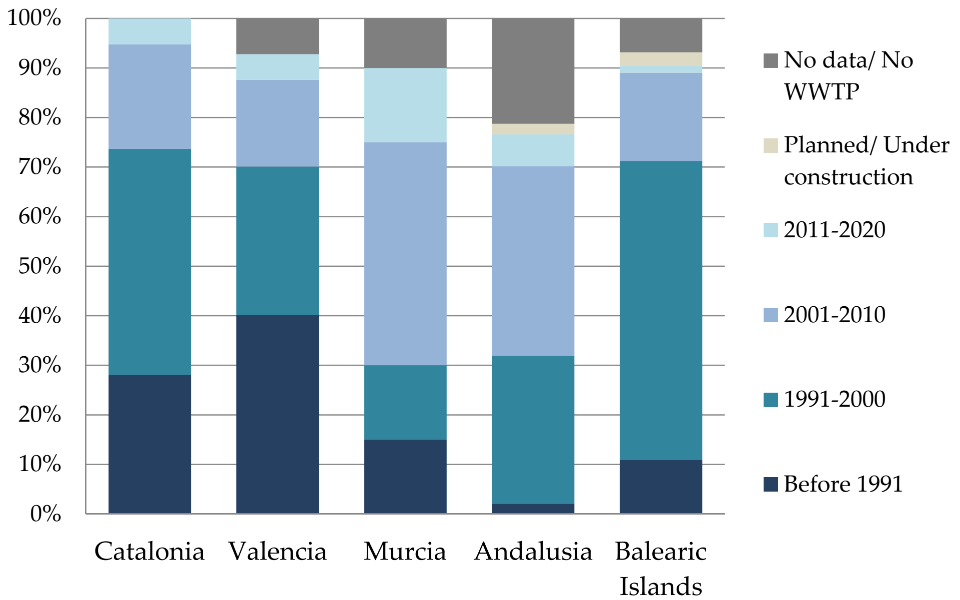

Figure 1. Classification of WWTPs according to the year of construction. Source: Authors.

WWTPs can collect and treat wastewater generated in the municipality where the plant is located or treat the wastewaters of supramunicipal or metropolitan areas. In this respect, the study area has characterized a marked difference between Catalonia, where about 50 per cent of the plants treat wastewater from a single municipality, and the rest, where the figure rises to 80 percent or more. This difference represents an example of the larger, more centralized WWTP model dominant in Catalonia in direct relationship with the weight of urban-industrial agglomerations of this region, especially Barcelona, contrasting with the smaller and more disperse model dominant in the rest of the area, with the exception of the city of Valencia (see Figure 2).

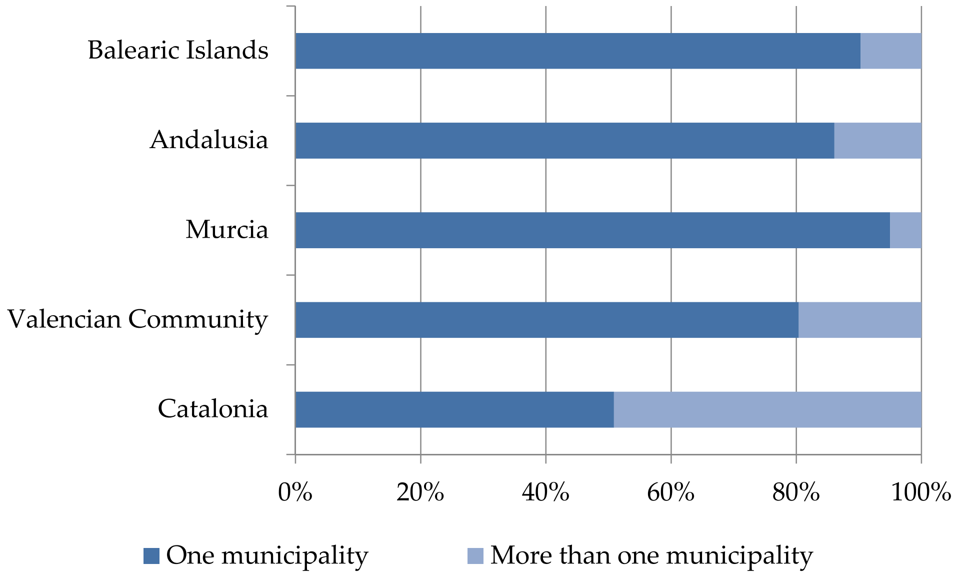

Figure 2. Percentage of WWTPs according to the number of municipalities served. Source: Authors.

In Figure 3, the same data is presented at the provincial scale. It can be noticed how in the province of Barcelona, just about one municipality out of ten treats its own wastewater only, while in the other two Catalan provinces, Girona and Tarragona, the figures rise to 60 and 70 percent, respectively. In all the remaining provinces, 80 percent or more of the municipalities treat only their own wastewaters. Plant capacity also relates well to the number of municipalities served, as in the case of Barcelona and the 2 WWTPs (El Prat de Llobregat and Besòs) serving most of the Metropolitan Area. The relative exceptions of the Andalusian provinces of Malaga and Granada with percentages somehow lower than the rest could be the result, in part, of insufficient data.

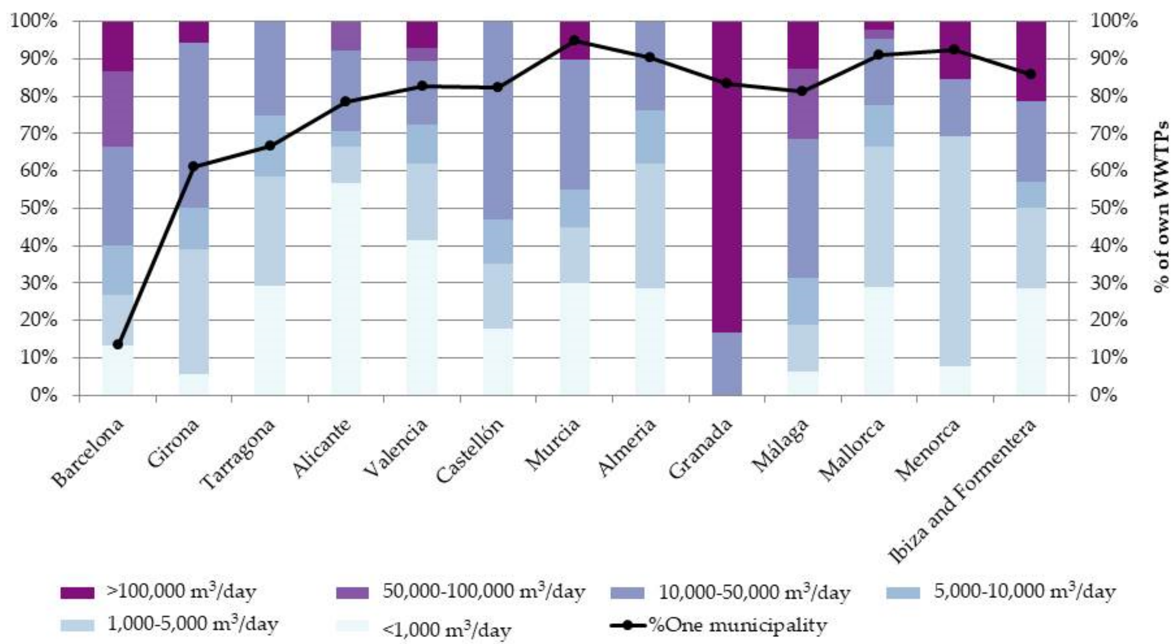

Figure 3. Percentage of WWTPs according to the number of municipalities served and plant capacity. Source: Authors.

3.2. Management

Regarding management, from Figure 4 it can be noted how, for the entire area, private companies oversee 66 percent of the plants, and, in collaboration with public entities (public–private partnerships or PPPs), an additional 20 percent (see Appendix B for ownership details of each major company). Public companies operate just 14 percent of the total, with numbers only significantly higher in Andalusia where they manage more than half of the plants. PPPs are dominant in Catalonia and Murcia, while private companies manage almost 87 percent of the WWTPs of Valencia (Figure 5).

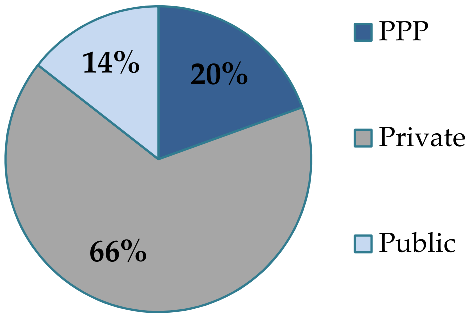

Figure 4. WWTP management per type. Source: Authors.

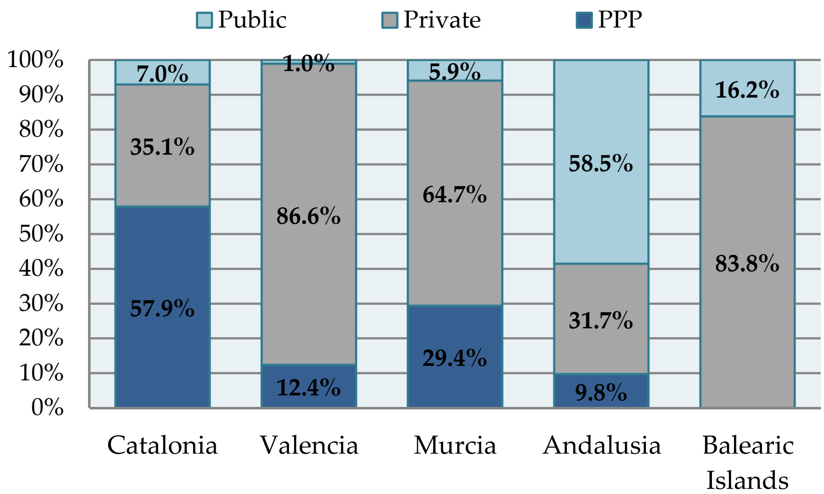

Figure 5. Classification of WWTPs based on management type per region. Source: Authors.

On average, the percentage belonging to public entities in Public–Private Partnerships (PPPs) represent less than 40 percent of the total capital of the company. Therefore, private companies not only control about two thirds of the WWTPs of the study area, but also more than 60 percent of the PPPs. The dominant company in wastewater treatment in the study area is the Agbar–Suez group, present in 52 plants, including some of the largest ones such as the four plants in the Metropolitan Region of Barcelona, and plants in the cities of Tarragona, Alicante, Elche, and Murcia. Other large companies include Ferrovial (20 plants, mostly in the Balearic Islands); ACCIONA (18 plants, in Catalonia and the Balearic Islands); and Aqualia (17 plants, mostly in Catalonia). Important regional companies are Aguas de Valencia (18 plants) and FACSA (23 plants), with presence in Valencia and the Balearic Islands.

Figure 6 attempts to determine whether a relationship between size and a dominant management type can be found from the data. However, no clear trend could be discerned, since private companies appear to lead all size segments except for the 50 to 100,000 m^3/day class.

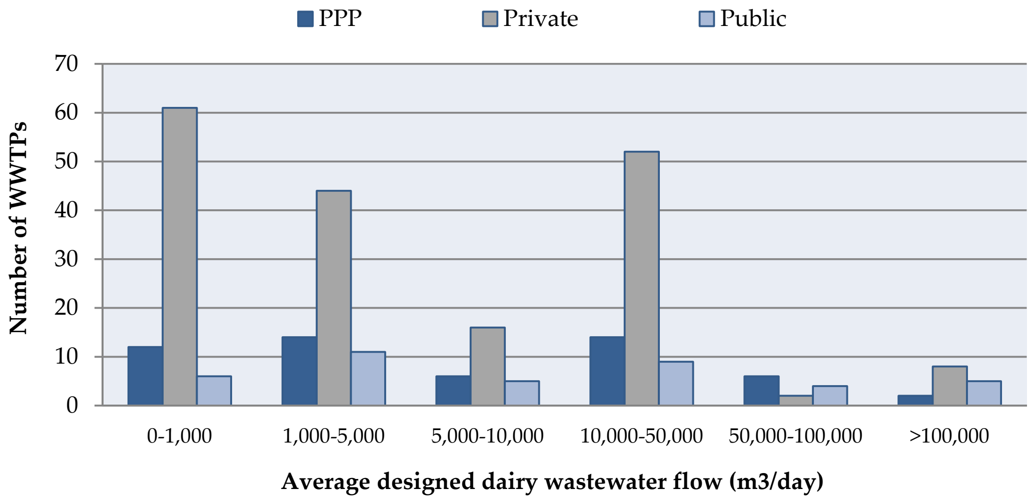

Figure 6. Classification of WWTPs based on management type and designed wastewater daily flow. Source: Authors.

3.3. Main Treatments

The main goal of WWTPs is to reduce or eliminate suspended solids and pollutants before discharging flows into the environment or making them available for reuse. Wastewater treatment must comply with minimum values for certain elements at discharge points according to the 1991 Directive on Urban Wastewater.

Table 3 represents a classification of wastewater treatments in the regions studied. The category with the largest number of WWTPs is biological treatment with nutrient removal and disinfection (tertiary treatment), followed by biological treatment alone. The categories with smaller numbers of WWTPs are those located at the extremes. Thus, the simplest treatment (lagoon) and the most sophisticated (biological with nutrient removal and advanced tertiary treatment) are both present in 10 plants each.

Table 3. Number of WWTPs per region according to type of treatment. Source: Authors.

Type of Treatment	Andalusia	Catalonia	Valencian Community	Balearic Islands	Murcia	TOTAL
Lagoon	5	2	0	3	0	10
Biologic	11	28	7	22	5	73
Lagoon + Biologic	3	0	0	4	0	7
Biologic + Nutrient removal [1]	0	6	13	21	1	41
Biologic + Tertiary Treatment [2]	10	10	16	3	3	42
Biologic + Advanced Tertiary Treatment [3]	11	0	1	1	0	13
Biologic + Nutrient removal + Tertiary Treatment [2]	1	9	57	12	8	87
Biologic + Nutrient removal + Advanced Tertiary Treatment [3]	0	2	3	2	3	10

[1] Nutrient removal includes the elimination of nitrogen or phosphorous or both. [2] Tertiary treatment in most cases involves a basic disinfection. [3] Advanced tertiary treatment includes reverse osmosis, micro- and ultrafiltration, electrodialysis, ozonisation, and symbiotic treatments.

According to Figure 7, Murcia is the region with the highest proportion of WWTPs using the more complete treatment type (biologic + nutrients removal + advanced tertiary).

Valencia presents a large percentage of tertiary treatment, mostly consisting of basic disinfection with UV or chlorine. Catalonia is the region where the proportion of biological treatment in the WWTPs is the highest.

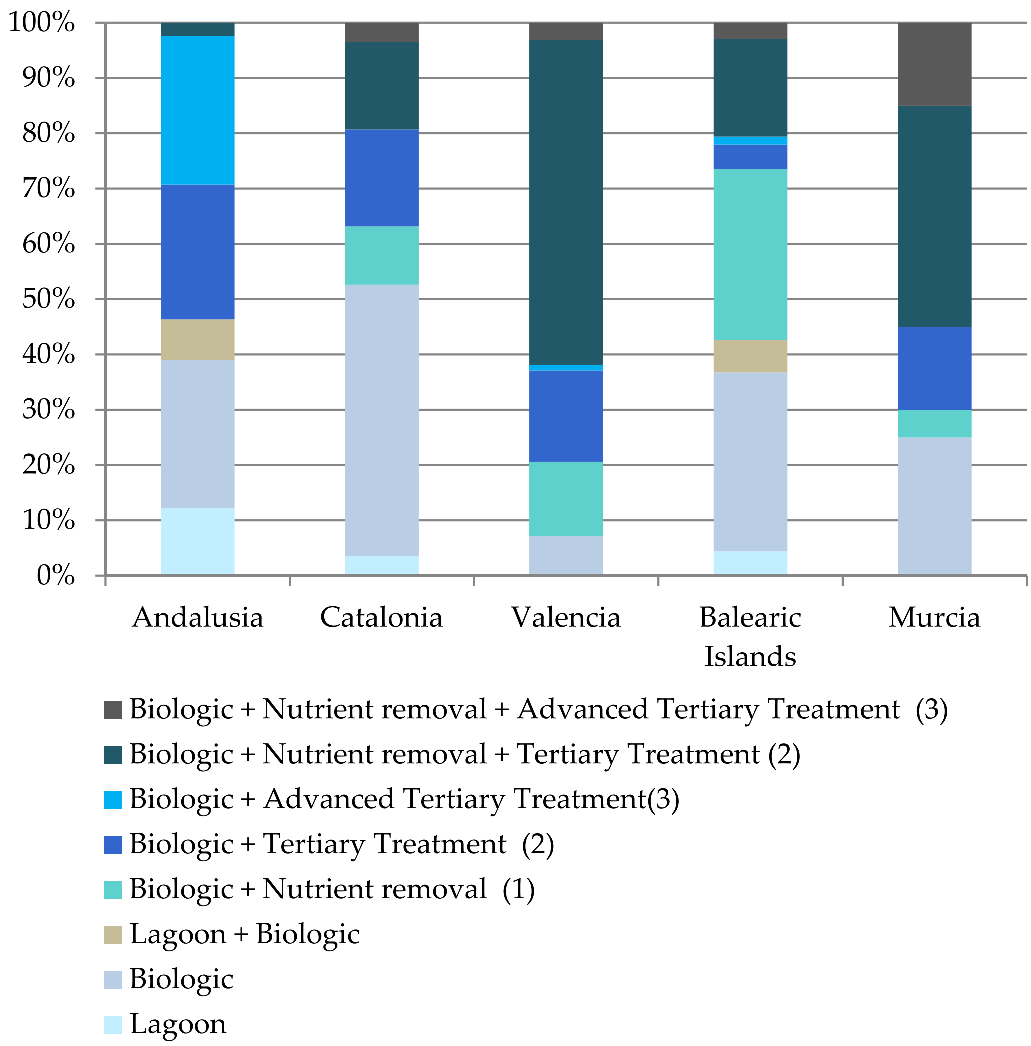

Figure 7. Classification of WWTPs based on treatment type per region. Source: Authors. (1) Nutrient removal includes the elimination of nitrogen or phosphorous or both. (2) Tertiary treatment in most cases involves a basic disinfection. (3) Advanced tertiary treatment includes reverse osmosis, micro- and ultrafiltration, electrodialysis, ozonisation, and symbiotic treatments.

Although no direct relationship can be established between capacity and treatment type, around 90 percent of the cases in the study area using the simplest treatment (lagoon) were WWTPs with designed wastewater flows below 5000 m^3/day. Biological treatment is common for all sizes, while more complete or sophisticated treatments with advanced processes are more common in the bigger WWTPs (Figure 8).

Table 4 lists the WWTPs using nutrient removal and advanced tertiary treatments: Three of them (El Prat de Llobregat in Catalonia, and Benidorm, and Alicante- Rincón del León in Valencia) are equipped with reverse osmosis technologies, while ultrafiltration is present in two other plants of the Valencia region.

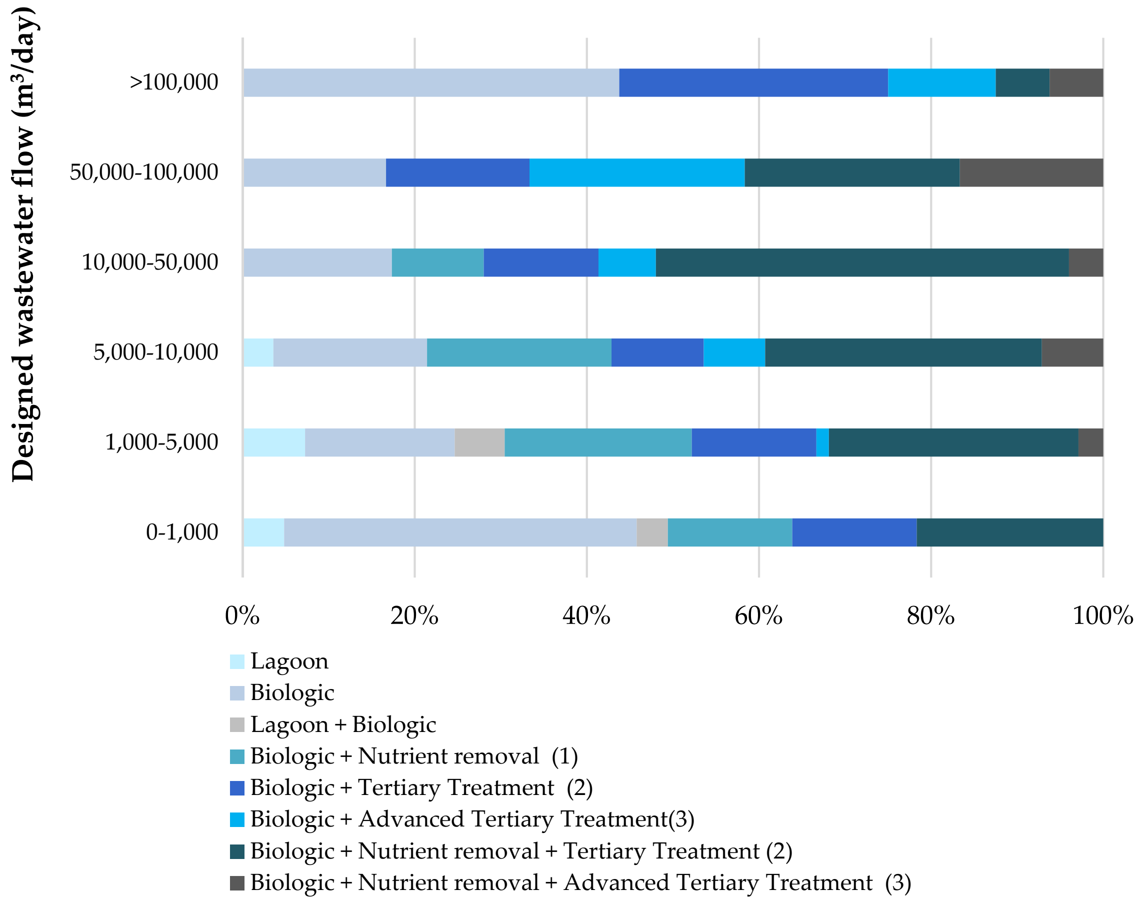

Figure 8. Classification of WWTPs based on treatment type and capacity. Source: Authors. (1) Nutrient removal includes the elimination of nitrogen or phosphorous or both. (2) Tertiary treatment in most cases involves a basic disinfection. (3) Advanced tertiary treatment includes reverse osmosis, micro- and ultrafiltration, electrodialysis, ozonisation, and symbiotic treatments.

Table 4. WWTPs with advanced tertiary treatments. Source: Authors.

WWTP Name	Region	Management	Primary Treatment	Secondary Treatment	Advanced Tertiary Treatment
El Prat de Llobregat	Catalonia	PPP	Primary decanter	Active Sludge	Ultrafiltration + reverse osmosis + reversible electrodialysis + filtration + physical and chemical treatment + disinfection
Gavà—Viladecans	Catalonia	PPP	Primary decanter	Active Sludge	Ultrafiltration+ post-chlorination
Benidorm	Valencia	Private	Primary decanter	Active Sludge	Ultrafiltration +reverse osmosis + post-chlorination
Teulada (Moraira)	Valencia	Private	-	Prolonged Aeration	Ultrafiltration + post-chlorination
Elche (Arenales) (*)	Valencia	PPP	-	MBR	Ultrafiltration + UV disinfection
(Alicante (Rincón de León)	Valencia	PPP	Primary decanter	Active Sludge	Filtration +Ultrafiltration + reverse osmosis + chlorination
San Pedro del Pinatar	Murcia	Private	-	Active Sludge-MBR	Microfiltration + UV disinfection

Table 4. *Cont.*

WWTP Name	Region	Management	Primary Treatment	Secondary Treatment	Advanced Tertiary Treatment
Águilas	Murcia	Private	-	Active Sludge—MBR	Microfiltration + Coagulation and flocculation + Filtration+ UV disinfection
La Hoya (Lorca)	Murcia	PPP	-	Active Sludge—double stage	Coagulation and flocculation + Filtration+ UV and Cl disinfection
Bendinat	Balearic Islands	Public	-	Prolonged Aeration	Filtration + Microfiltration + UV and Cl disinfection
Alcúdia	Balearic Islands	Public	-	Prolonged Aeration	Filtration +Ultrafiltration + UV and Cl disinfection

(*) We thank one reviewer for an update on this WWTP.

Total and average designed flows (in m^3/day), according to management category (public, PPP and private), are presented in Figure 9. In terms of total flows, PPPs manage some 1763 million m^3/day, followed closely by private companies (1757 million m^3/day), while public operators oversee approximately half the previous flows (831,399 m^3/day). However, regarding daily average flows per category, PPPs (32,648 m^3/day) and public companies (23,094 m^3/day) stand far ahead of private companies. In general, therefore, the largest WWTPs are managed by either by PPPs or public companies, while the smaller plants are mostly managed by private companies.

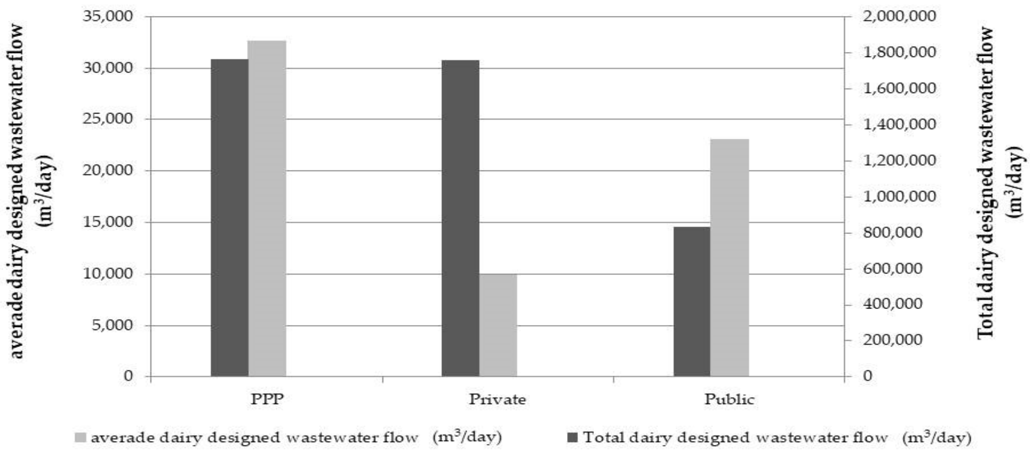

Figure 9. Average and total daily flows by management type. Source: Authors.

A similar pattern can be found regarding treatment systems. Figure 10 shows that almost 80 percent of the plants performing the most advanced treatments are managed by PPPs and private companies. For the remaining categories of treatment systems, private companies dominate.

3.4. Uses of Treated Wastewater Water

The use of treated wastewater depends on the type of treatment and the final destination of the treated effluent. The flows of 44 percent of the WWTPs in the database are partly or totally reused; in 47 percent of the plants they are not, and there is no information for the remaining 9 percent. Figure 11 shows percentages of WWTPs with water reuse per region. It can be seen how Murcia has the highest proportion, with 80 percent of the treated effluent being reused. The large percentage with no information for the case of Catalonia probably corresponds to flows being returned to natural media (rivers or the sea), since it is open to interpretation as to whether these flows perform environmental functions or not.

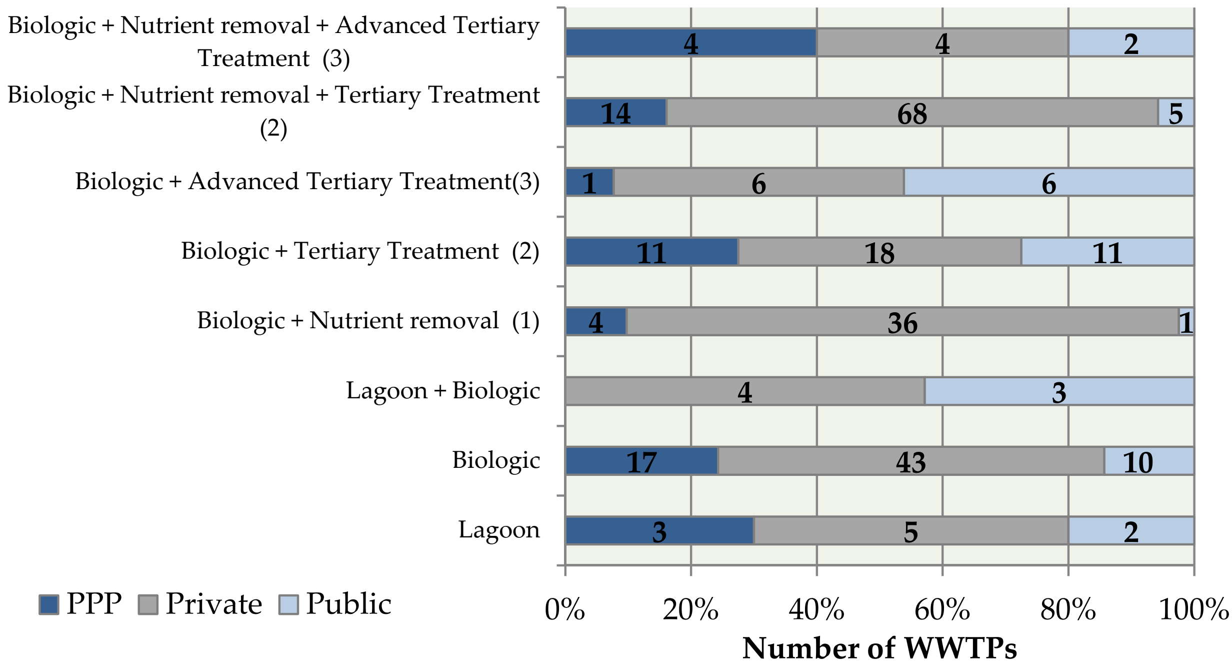

Figure 10. Treatment system by management type. Source: Authors. (1) Nutrient removal includes the elimination of nitrogen or phosphorous or both. (2) Tertiary treatments in most cases involve a basic disinfection. (3) Advanced tertiary treatment includes reverse osmosis, micro- and ultrafiltration, electrodialysis, ozonisation, and symbiotic treatments.

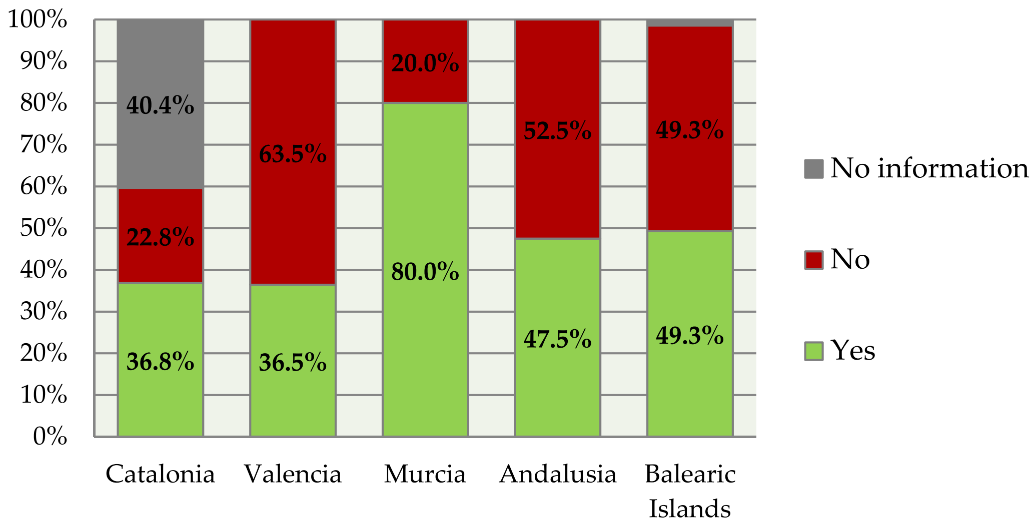

Figure 11. Water reuse by WWTPs per region. Source: Authors.

Figure 12 extends this analysis by adding information about tertiary treatment. Tertiary treatment produces higher quality wastewater flows, better suited for a larger variety of possible uses. Sixty-two percent of WWTPs reusing their effluent have a tertiary treatment. On the other hand, of the WWTPS that do not reuse treated flows, 37 percent also carried out a tertiary treatment.

In Figure 13, wastewater being reused is related to the type of treatment. In general, the more complex the treatments, the higher the possibility of reuse, especially in WWTPs with basic or advanced tertiary treatments.

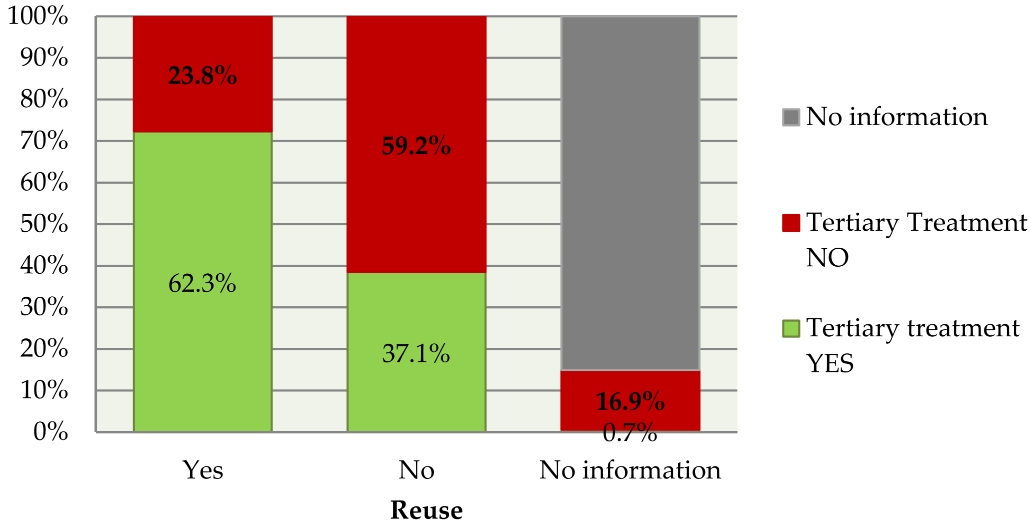

Figure 12. Water reuse by WWTPs per region. Source: Authors.

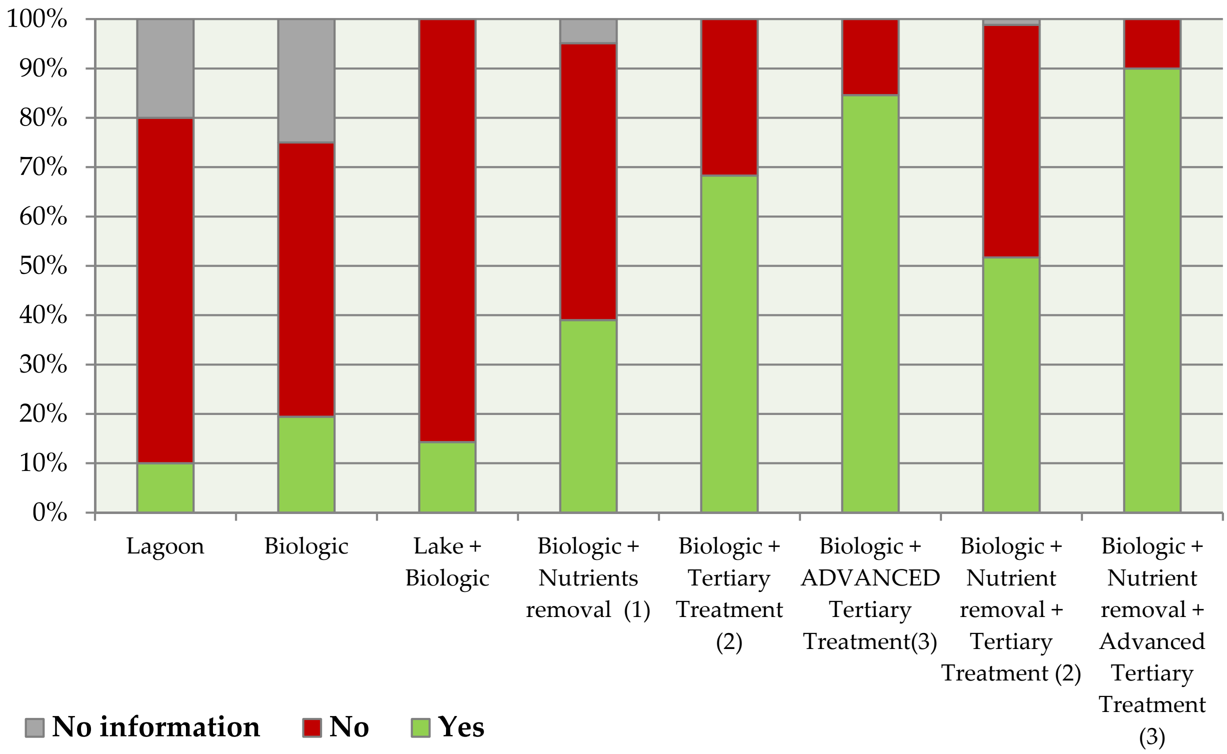

Figure 13. Wastewater reused according to type of treatment. Source: Authors.

Figure 14 represents the distribution of final uses of the treated wastewaters in the different regions. More than 70 percent of treated wastewater in Valencia and more than 90 percent in Murcia are reused in agricultural irrigation. Water quality demands for this particular use do not generally require tertiary treatment, and effluents can be reused with simpler interventions. In the Balearic Islands, agricultural and leisure uses are equally important, the latter especially related to the irrigation of golf courses. In Andalusia, treated wastewater is mostly reused in golf courses, public parks, and gardens, while Catalonia presents the most diverse variety of possibilities, with a certain prevalence of leisure and also environmental uses, probably related to the supply of water flows to wetlands and other water-dependent ecosystems. Likewise, industrial and public urban uses also appear as important.

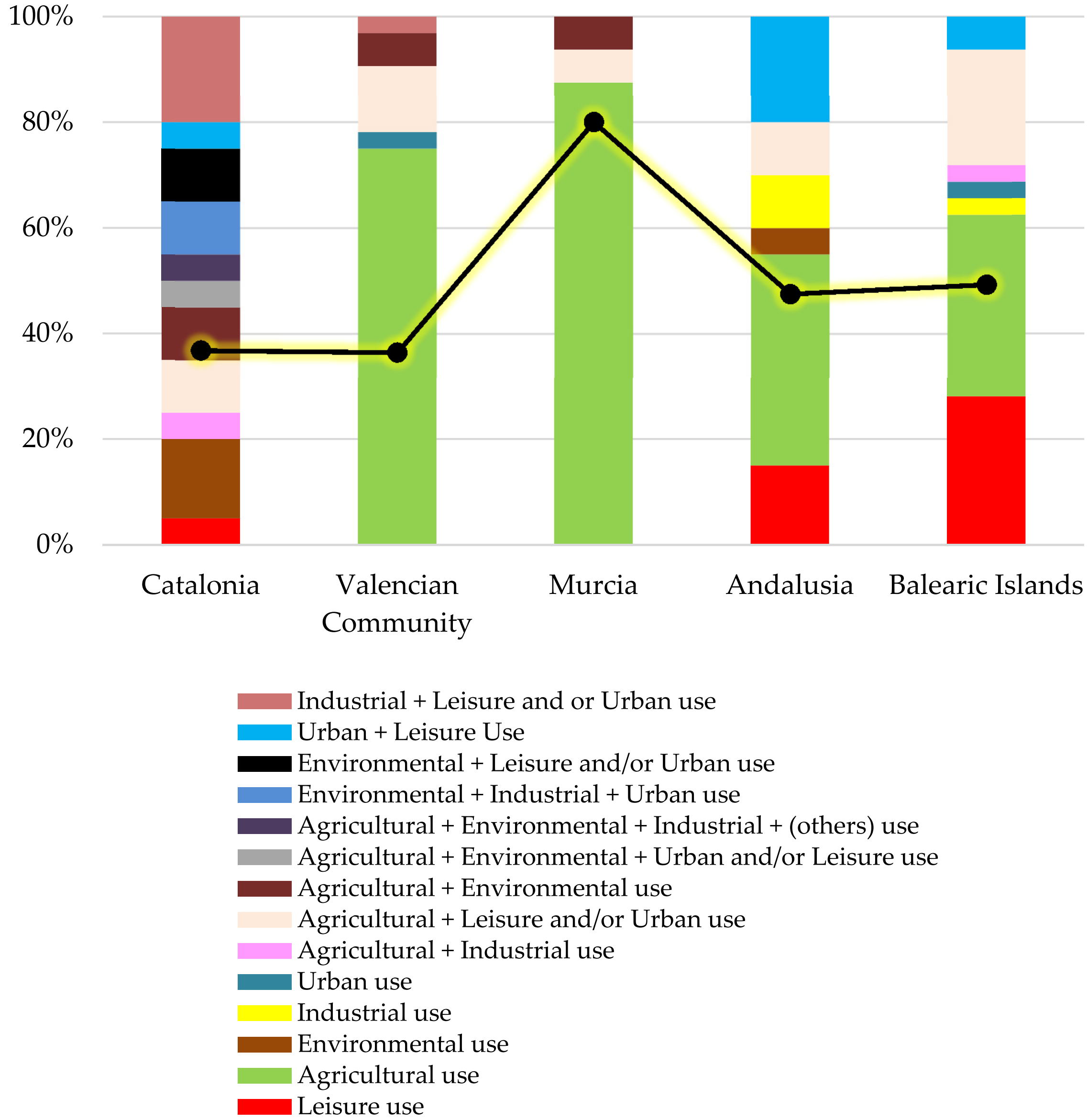

Figure 14. Final destination of reused wastewater per regions. Source: Authors.

4. Discussion

4.1. Location

As seen from the results presented in the previous section, the number and characteristics of WWTPs in Mediterranean Spain picture a situation of heterogeneity that nonetheless harbors an important potential for confronting future periods of water stress with new flows in significant quantities [7]. The objective of treating polluted flows has been generally achieved, and the ecological status of surface and groundwater, while still far from being optimal, is much better than three decades ago, in part thanks to the European Water Directive of 2000 [30]. Still, compliance with European regulations is not yet complete and effluents in certain plants, especially in Andalusia, fail to meet minimum European standards. Of the regions included in our study area, Andalusia (provinces of Almeria, Granada and Malaga) is not only the region where the construction of new WWTPs is more recent (contrary to Catalonia, Valencia and the Balearic islands where 60 percent of the plants were built before 2001), but also the region with most municipalities lacking a WWTP because they do not reach the 2000 inhabitant equivalent threshold set by the 1991 EU Directive. In addition, the operation of some of these WWTPs fails to produce wastewaters of enough quality, and problems related to certain parameters (BOD, COD, among others) remain important [30].

4.2. Management

A significant characteristic of WWTPs in Mediterranean Spain (with the possible exception of Andalusia) is the weight of the private sector, either alone or in combination with public companies, establishing a parallel with the equally widespread presence of private companies in urban water supply [31]. Although some private or PPP companies managing WWTPs are local or regional in scope, others belong to global water utilities, most notably Agbar-Suez, the leading water supply and sanitation company in the area. Likewise, some of the most important Spanish construction companies, such as ACCIONA or Ferrovial, are also present in the wastewater treatment sector. The interest of these large companies in water-related businesses is not fortuitous. Until the crisis of 2008, Mediterranean Spain recorded the highest rates of economic growth in the country, deeply rooted on urban and tourist development [32]. Hence, opportunities for investments in the water cycle of rapidly expanding cities or for gaining municipal concessions for managing water supply and sanitation services became attractive business options for these companies. In 2019, wastewater treatment in Spain moved around 1.3 billion euros with small but sustained rates of growth in the past years. Forty-seven percent of the income generated by WWTPs concentrates in five companies [33].

A management model of WWTPs based on private companies and on public–private partnerships with a strong role for the private partner has as a primary objective the production of an effluent able to comply with the legal requirements regarding quality that can be released back into the aquatic environment. However, these effluents may also be reused and, in some cases, this may open a window of opportunity for companies seeking to expand their activities. Next, the situation of the study area regarding uses of reclaimed water is discussed in detail.

4.3. Irrigation

Agricultural irrigation is, by far, the main destination of reclaimed flows in the study area, especially in Valencia and Murcia. Both regions share several environmental, economic, and territorial characteristics that help to explain the relevance of water reuse. First, agriculture has specialized in relative high value fruit and vegetable produce, taking advantage of favorable temperatures and adequate soils which facilitate agricultural production mostly for export, especially in areas such as Almeria [34]. However, given insufficient and irregular precipitation, irrigation becomes necessary and, traditionally, wastewaters originating in nearby cities have been used to complement the water flows needed for growing crops. Proximity to urban centers, scarce and unreliable conventional water flows, and competitive advantages in European markets therefore explain water reuse for irrigation which, on the other hand, does not usually necessitate large plants or very sophisticated or expensive treatments. Murcia WWTPs stand out as the most significant example of this option for water reuse, with around 55 hm^3/year at a cost of 0.8 euros/m^3 of water. Although farmers express their desire for better quality flows, they appear to be nonetheless relatively satisfied with treated flows which are far cheaper than desalinated water [35]. Irrigation communities are the main beneficiaries of reclaimed water and in some cases they may participate in companies managing WWTPs. In this sense, Valencia and Murcia are no different from many other areas of the world in which agricultural orchards are located close to urban areas and can therefore benefit from wastewater flows [36]. However, although the use of treated wastewater in irrigation should not necessarily imply rejection by users [37], a certain level of risk always persists and it remains to be seen whether the new European regulation on water reuse for agricultural irrigation will impose stricter controls on current practices in both regions.

One interesting and perhaps unique example of agricultural water reuse involves the large tourist resort of Benidorm (one of the most important of the Mediterranean) specializing in mass tourism and the agricultural areas nearby. Benidorm has experienced severe problems of water supply in the past, with a near collapse of the city in the late 1970s that gravely affected the tourist industry [38]. Since then, the objective has been to improve efficiency in water use and to develop a portfolio of diverse water supply options including desalination. One important asset in this portfolio is the possibility of using high quality groundwater from nearby mountains, historically owned by irrigation communities. The water authority of the Benidorm area (Consorcio de Aguas de la Marina Baja) built a wastewater plant with tertiary treatment to which an extra unit with reverse osmosis technology (besides conventional pollutants, the wastewaters from Benidorm also have high salt content) was added, so that the resulting effluent could be used for irrigating the fruit orchards of the surrounding agricultural communities. In exchange, in times of drought, these communities would relinquish their rights to the aquifer water to the city. Hence the WWTP of Benidorm produces high quality reclaimed water which is passed on to irrigators at no cost, in exchange for clean water [39].

In contrast, in other regions such as Catalonia, agricultural water reuse is relatively small for reasons that have to do with the higher availability of conventional water resources in the big irrigation areas and, to a certain extent, with the important physical distance between large urban centers (East) and the most important irrigation areas (West and South). Hence, only six per cent of reclaimed water is used in agricultural irrigation [40].

4.4. Leisure and Urban Uses

The most significant item within the category of reuse for leisure purposes is the irrigation of golf courses. Golf courses proliferated in Mediterranean Spain during the construction boom of 2000–2008. Many of these new, high-end residential developments included a golf course as an attraction to boost sales. In our study area, most courses are located in Andalusia, especially in the province of Malaga (about 50 or half the total number in the region) [41]. As of 2020, Catalonia had 41 courses, Valencia 38, the Balearic Islands 22, and Murcia 19 [42]. The last three regions and especially Valencia and Murcia showed the fastest development. For example, in Valencia, between 2005 and 2010, the number of golf courses went from 21 to 33. About 30 more remained unfinished when the real estate bubble collapsed from 2010 onwards [43,44].

Given the generally high requirements for maintaining grass cover, one of the main constraints for the development of golf courses is water. On average, an 18-hole golf course consumes between 1500 and 2000 m^3/day during the period of maximum irrigation, usually summer, or up to 300,000 m^3 per year [45]. The temporal coincidence with agricultural and golf-related demand adds pressures on available water resources; hence the interest in non-conventional resources such as reclaimed water increasingly required by legal regulations at the regional level. Since the late 1980s, all regions in the study area have passed legislation to make the use of reclaimed water mandatory for golf irrigation where possible [46]. ACOSOL, a public company managing 7 WWTPs in Andalusia, has become the largest provider of irrigated water for golf courses in Europe, supplying about 7 Hm^3 of water annually to 36 golf courses in the Costa del Sol tourist area [47].

Treated wastewater is also used for municipal purposes such as street cleaning and park and garden irrigation. For example, the two WWTPs in Alicante supply reclaimed water to irrigate 70 percent of the public parks and gardens in the city. Moreover, they also contribute reclaimed water to the permanent pond built in the Parc de La Marjal, near the beach, and occupying a floodable area [48]. The private company Hidraqua (a subsidiary of Agbar) offers reclaimed water for municipal uses in towns such as Elche, Torrevieja and Orihuela. Moreover, as a holder of 50% of capital of "Aguas de Alicante", the company supplying water to the city, Hidraqua participates in the project of bringing reclaimed water for irrigation purposes to a residential neighborhood, with a total investment of 8.7 million euros in a new pipe system transporting reclaimed water from the Rincon de Leon WWTP. These flows will be sold to residents at 0.32 euros/m^3, that is, about 20 percent of the price of water from the regular network. This is perhaps the first example in Spain of reclaimed water being sold to private customers, showing the potentialities of this resource in commercial terms [49].

4.5. Environmental Uses

Environmental uses for reclaimed water cover a large spectrum of options widely represented in the study area. In some cases, reclaimed flows with environmental functions are combined with reuse for agricultural irrigation. For example, the Pinedo WWTP in Valencia recycles some 78 hm^3/year for irrigation and environmental restoration of the Albufera natural park [50]. In this case, however, environmental managers are reluctant to use wastewater from this plant because of the limited capacity to deal with nutrient loads and the potential of ecological damage to the park ecosystems.

Proportionally, the region directing the most reclaimed flows to environmental uses is Catalonia (around 57 percent of the total in 2019) [40]. Other than the supply of reclaimed water to the Aiguamolls de l'Empordà Natural Park (a coastal wetland in the north of the region) [51], perhaps the most significant environmental use for reclaimed water in this region is the injection of flows from the El Prat WWTP into the aquifer of the Llobregat River Delta, long affected by processes of saltwater intrusion caused by overpumping and by the extension of the Barcelona harbor [52]. In 2007, operations began to build a hydraulic barrier to contain salinization through three wells injecting 2500 m^3/day of reclaimed water. 50 percent of the water came from the WWTP, while the other 50 percent was water from the regular network. By 2010, 11 additional wells were added injecting up to 15,000 m^3/day. The drought of 2008 and the need to save potable water motivated the decision for reclaimed water to be the only source for the hydraulic barriers. However, due to the economic crisis and budgetary constraints, the program was abandoned in 2011, despite the successful results in improving the quality of groundwater. Early in 2017, aquifer recharge with reclaimed water was resumed and plans were to increase reclaimed flows to improve river water quality and wetland ecosystems of the river delta [53].

4.6. Industrial Uses

Industrial reuse includes treated flows that are circulated within industrial plants as part of treatment processes. The use of reclaimed water for industrial purposes is also important in Catalonia, especially in the petrochemical complex of Tarragona, one of the most important in the Western Mediterranean, and supplied by two WWTPs (Tarragona and Vilaseca) equipped with advanced tertiary treatments. Part of the reclaimed flows from these WWTPs also provides for the landscaping needs of the Port Aventura Amusement Park, located nearby [54]. The widely supported initiative to use reclaimed water from the El Prat WWTP for the industrial area of Zona Franca, in Barcelona, has not succeeded yet despite the possibility of liberating groundwater for uses needing higher water quality [55].

4.7. Potable Uses

Potable reuse, as mentioned before, is one of the main potential destinations of reclaimed water and may become the alternative water resource of the future in certain areas of Mediterranean Spain. At the moment, however, according to Spanish legislation, the direct use of reclaimed water for drinking is prohibited. However, if environmental media such as rivers or aquifers can be incorporated into the overall treatment process, this constraint can be removed and reclaimed water can be indirectly reused even for drinking purposes [56,57].

Although WWTPs equipped with advance tertiary treatments (including ultrafiltration and reverse osmosis) are able to produce an effluent of a quality comparable to flows entering drinking water plants, potable water reuse, even indirectly, is not present in the study area where the alternative to conventional resources is desalination. There are, however, two initiatives on indirect potable reuse worth commenting on.

The first concerns the beach town of Port de la Selva in Northern Catalonia. Tourist development and the increase in population during the summer have placed water quantity and quality under stress, especially during periods of drought. A pilot project with European funding used treated wastewater to recharge the local aquifer off season. Flows resulting from mixing aquifer water with treated wastewater could be pumped back to the municipal water supply network. Water quality tests, however, showed that the salt content was still high (probably due more to seawater intrusion into the local aquifer than to reclaimed water), implying that a reverse osmosis system would be needed at the WWTP. Although costly, this option is economically more efficient than bringing surface water from inland [58].

The second case, in the Metropolitan Area of Barcelona, involves a project of indirect water reuse with the Llobregat River as the environmental medium. During the drought episode of 2007–2008, when water had to be supplied to Barcelona by sea tanker, an experimental plan was developed by the Catalan Water Agency and other organizations to pump reclaimed water from the El Prat de LLobregat WWTP upstream through a pipe to the Sant Joan Despí drinking water plant. Treated water would then be released into the river and, mixed with river water, flow for some 8 km downstream before intake by the drinking water plant supplying Barcelona. The quality of the effluent coming out of the WWTP is even better in some cases than the quality of river water itself thanks to the advanced tertiary system complemented with reverse osmosis [59]. During the drought of 2016–2017, with water levels in reservoirs at 43 percent of their capacity, the possibility of using reclaimed water from the El Prat WWTP was given serious consideration again, in case levels further declined to 25 percent of capacity. This stage was not reached, but a group of experts was convened to discuss and eventually recommend the use of reclaimed water for indirect potable purposes on a steadier basis and outside drought periods to guarantee water security for Barcelona [60]. The El Prat WWTP is an example of the dilemma faced by the larger and more modern plants: a high capacity of producing relatively clean water not matched by a comparable demand. In fact, the actual production of reclaimed water by this plant is only 0.7 percent of its capacity of 300 million liters per day [61].

Despite the important gap between treated water and water finally reused, in certain cases, conflicts may involve reclaimed water as well. For example, in 2017, the town of Torrevieja (Alicante) had to stop using reclaimed water for street cleaning and garden irrigation after a court sentence adjudicated reclaimed flows from the WWTP to two agricultural irrigation communities which held previous rights to these flows [62]. Drought conditions, the high price of desalinated water, and the increasingly scarce flows from the Tajo-Segura diversion make reclaimed water a critical resource for farmers in this area, which in turn may compromise other potential uses.

5. Conclusions

This paper has examined the current situation of wastewater treatment plants in Mediterranean Spain, one of the most dynamic areas of the country but also one the areas experiencing major water stress. This assessment has been made focusing on governance; type of treatment, and water reuse practices using a database of 279 plants in the regions of Catalonia, Valencia, Balearic Islands, Murcia, and Andalusia. Future work would need to consider the assessment of effluent values at the end points of plants both for legal requirements and, given the new European regulation on agricultural reuse, for quality requirements concerning treated wastewater.

European legislation, and particularly the 1991 Directive on wastewater, has been paramount in the expansion of WWTPs in the study area, both in number and in complexity of treatments. Given the limited contribution that surface water and groundwater can make to improve quality through dilution, sophisticated treatments intensive in energy, such as reverse osmosis, may be needed to obtain effluent of a sufficient quality. Despite its efforts, Spain is still heavily fined for not complying with the Directive requirements and part of the affected WWTPs are in the study area, especially Andalusia.

In governance terms, private companies manage most WWTPs either alone or participating in PPPs in which (as in the Metropolitan area of Barcelona) they may have most of the shares. Large international and Spanish water utilities are present in the study area, often in charge of plants with advanced treatment. Although the main activity is treating wastewater flows to acceptable quality levels, some companies are also selling reclaimed water to individual users. Activities such as the irrigation of golf courses or certain industrial uses may also be spaces of business opportunity for companies.

In terms of reuse, agricultural irrigation remains by far the largest sector, and this is likely to intensify in the future because of conventional supplies becoming scarcer and desalination being too expensive. However, treated wastewater itself may become scarce as well and conflicts may appear, as the example from Torrevieja shows.

However, the great hope placed in reclaimed water is their potential in contributing to urban water supplies through direct or, more likely, indirect means. Again, this can be the "resource for the future" that many stakeholders of very different backgrounds and political positions agree with. In our study area, the Metropolitan Area of Barcelona appears to be well positioned to pursue such an initiative in the near future to face drought events.

However, WWTPs will need to face new challenges, such as the increasing presence of new pollutants in very small concentrations; the nexus between stormwater and wastewater (and the possibility of WWTPs being affected by increasingly high flows from storms linked to climate change, capable of collapsing the plants); or the conversion of WWTPs into biofactories, substituting energy consumption and waste generation with energy production and resource recovery. Social learning regarding treated wastewater has made important progress, but whether citizen awareness and acceptance of these flows for drinking and bathing matches the consensus reached within the scientific and technical communities regarding this new resource remains to be seen.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. List of Web Sources for the Elaboration of the Database

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ackURL=%2Fes%2Fweb%2Fecologia%2Faigua%2Finstalacions-i-equipaments%2Fllistat&_EquipamentSearchListPortlet_WAR_AMBSearchPortletportlet_format=map&_EquipamentSearchListPortlet_WAR_AMBSearchPortletportlet_type=medi_ambient.aigua_depuradora. Last accessed 30 March 2020.

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Appendix B. Management Regime and Ownership Composition of Wastewater Treatment Companies in the Study Area

<table>
<tr><th>Company</th><th>Management</th><th colspan="2">Ownership Composition</th></tr>
<tr><td rowspan="3">Bold SIMMAR (Serveis Integrals del Maresme SL)</td><td rowspan="3">PPP</td><td rowspan="2">80% AQUAGEST MEDIOAMBIENTE—RUBATEC—AMSA [PPP]</td><td>90% AQUAGEST MEDIOAMBIENTE—RUBATEC [Private]</td></tr>
<tr><td>10% Aigües de Mataró S.A (AMSA)</td></tr>
<tr><td>20% Consell Comarcal del Maresme [Public]</td><td></td></tr>
<tr><td rowspan="3">Aigües de Barcelona, Empresa Metropolitana de Gestió del cicle integral de l'aigua S.A.</td><td rowspan="3">PPP</td><td colspan="2">70% Societat General d'Aigües de Barcelona (SGAB)—Agbar Group [Private]</td></tr>
<tr><td colspan="2">15% Criteria Caixa [Private]</td></tr>
<tr><td colspan="2">15% Àrea Metropolitana de Barcelona [Public]</td></tr>
<tr><td>Remondis- Agua SAU</td><td>Private</td><td colspan="2">Since June 2020, the company for water management in Spain, which has been known as OMS-SACEDE S.A.U. for more than 10 years, has changed its corporate name to REMONDIS AGUA S.A.U.</td></tr>
<tr><td>AQUAMBIENTE SERVICIOS PARA EL SECTOR DEL AGUA SAU</td><td>Private</td><td colspan="2">It seems to be part of AQUOLOGY, which belongs to SUEZ</td></tr>
<tr><td rowspan="2">Empresa Mixta d'Aigües de la Costa Brava, SA (EMACBSA)</td><td rowspan="2">PPP</td><td colspan="2">33.3% Consorci de la Costa Brava</td></tr>
<tr><td colspan="2">66.7% AIE Aqualia Gestión Integral del Agua, SA (Aqualia)—SOREA SAU</td></tr>
<tr><td>SOREA SAU</td><td>Private</td><td colspan="2">Agbar Group</td></tr>
<tr><td>AQUALIA</td><td>Private</td><td>51% Grup de serveis ciutadans FCC</td><td>49% IFM Investors (australian ethical fund)</td></tr>
<tr><td>ACCIONA AGUA, S.A.U.</td><td>Private</td><td colspan="2">ACCIONA Group</td></tr>
<tr><td rowspan="3">UTE SORIGUÉ-SAV-DAM (UTE EDAR TORREDEMBARRA)</td><td rowspan="3">Private</td><td colspan="2">SORIGUÉ S.A. [private]</td></tr>
<tr><td colspan="2">DAM—Depuración de Aguas del Mediterráneo, S.L. [private]</td></tr>
<tr><td colspan="2">SAV—Agricultores de la Vega de Valencia S.A. [private]</td></tr>
<tr><td rowspan="2">Empresa Mixta d'Aigües d'Altafulla</td><td rowspan="2">PPP</td><td colspan="2">51% Altafulla City Council [public]</td></tr>
<tr><td colspan="2">49% Companyia General d'Aigües de Catalunya S.A. [private- Global Omnium subsidiary]</td></tr>
<tr><td>Aguas de Valencia S.A. (AVSA)</td><td>Private</td><td colspan="2">Originates Global Omnium</td></tr>
</table>

Company	Management	Ownership Composition	
Empresa Municipal Mixta de Aguas de Tarragona (EMATSA)	PPP	**51%** Tarragona City Council [public]	
		49% SOREA [private- **Agbar Group**]	
COMAIGUA S.L	PPP	**51%** Consell Comarcal del Baix Camp	
		49% SOREA [private- **Agbar Group**]	
Global Omnium Medio Ambiente	Private	Global Omnium subsidiary. Originated by **Aguas de Valencia**	
HIDRAQUA S.A.	Private	Belongs to Aigües de Barcelona [private- **Agbar Group**]	
UTE SAV-DAM-FACSA	Private	DAM—Depuración de Aguas del Mediterráneo, S.L. [private]	
		SAV—Agricultores de la Vega de Valencia S.A. [private]	
		FACSA [private- Grupo Gimeno]	
Aguas de Calpe	PPP	**40%** Calpe City Council [public]	
		60% Serhico, S.A. [PPP]	**40%** EGEVASA [PPP]
			60% AVSA [Private]
EGEVASA Empresa General Valenciana Del Agua SA	PPP	**51%** Diputación de Valencia [public]	
		49% Vainmosa Cartera [private- Global Omnium]	
AMAEM S.A., Aguas Municipalizadas de Alicante, E.M.	PPP	**50%** Alicante City Council [public]	
		50% por Hidraqua, Gestión Integral de Aguas de Levante S. A. [private- Suez)	
Aigües i Sanejament d'Elx	PPP	**51%** Elche City Council	
		49% por Hidraqua, Gestión Integral de Aguas de Levante S. A. [private- Suez)	
EXMAN S.L.	Private	-	
PAVAGUA	Private	PAVASAL Group	
AGAMED (Empresa Mixta Aguas del Arco Mediterráneo, S.A)	PPP	**26%** Torrevieja City Council	
		50% por Hidraqua, Gestión Integral de Aguas de Levante S. A. [private- Suez)	
IVEM S.L.	Private	-	
UTE EDAR PEÑÍSCOLA	Private	Dragados SA [private]	
		Asedes Infraestructuras SAU [private]	
TECVASA	Private	-	
SANEAMIENTO VALENCIA UTE (ACCIONA AGUA)	Private	ACCIONA Group	
UTE GOMA-SAV-DAM	Private	GOMA [private- Global Omnium]	
		DAM- Depuración de Aguas del Mediterráneo, S.L. [private]	
		SAV- Agricultores de la Vega de Valencia S.A. [private]	
Aigües de Cullera S.A.	PPP	**52.38%** Cullera City Council [public]	
		47.62% por Hidraqua, Gestión Integral de Aguas de Levante S. A. [private- Suez)	
ELECNOR S.A.	Private	Mother of a big group	
CADAGUA	Private	Grupo Ferrovial	
HIDROGEA	Private	Suez	

Company	Management	Ownership Composition
Aguas de Lorca	PPP	**51%** Lorca City Council [public]
		49% por Hidraqua, Gestión Integral de Aguas de Levante S. A. [private-Suez)
CODEUR S.A.	PPP	**51%** Vera City Council [public]
		23% CLIMASOL (S.A.T.) [private]
		26% FCC Aqualia, S.A. [private]
Empresa Mixta Municipal de Aguas de Níjar (EMANAGUA S.A.)	PPP	Nijar City Council [Public]
		Aqualia [private- FCC Group]
HIDRALIA	Private	Unicaja Banco S.A. [private]
		Suez Agua Concesiones Ibérica, S.L.U. [private]
Aguas y Servicios de la Costa Tropical de Granada AIE	Private	ACCIONA Group
		Aqualia [private- FCC Group]
Aguas de Narixa, S.A.	PPP	Nerja City Council [public]
		Aqualia [private- FCC Group]
HIDROBAL	Private	Agbar Group
Melchor Mascaró S.A.	Private	-
SOCAMEX	Private	Urbaser Group [private]

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