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# Analysis of Environmental Taxes to Finance Wastewater Treatment in Spain: An Opportunity for Regeneration?

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**Abstract:** The treatment of wastewater, financed through environmental taxes, is key to the development of a sustainable economy. The objective of this study is to verify whether the tax loads on wastewater discharges applied in Spain are effective, allowing the costs of secondary and tertiary treatments to be financed. First, the revenues collected from taxes related to the discharge of wastewater in the different Spanish regions, which reach an average value of 0.72 €/m$^3$, are analysed. Second, the costs of secondary wastewater treatment, prolonged aeration, activated sludge with nutrient removal, and activated sludge without nutrient removal are studied. Additionally, the costs of tertiary treatments, with environmental objectives and for reuse purposes, are considered. The analysis carried out reveals high heterogeneity in the amounts collected through taxes in the different Autonomous Communities. In some cases, these amounts do not cover the costs of the treatments. An urgent review is therefore required of the financing systems applied in order to secure a level of income that can cover all the exploitation and investment costs incurred.

**Keywords:** sanitation; depuration costs; depuration treatments; reuse; sanitary tax

## 1. Introduction

The importance of water for human development, the environment, and the economy justifies that the UN considers "clean water and sanitation" to be one of the 17 global objectives of the new agenda for sustainable development 2030 to guarantee universal access to safe, affordable drinking water [1]. Conventional water resources currently have environmental and economic constraints. The increasing imbalance between water extraction and natural recharge is aggravated by climate change, causing an increase in the cost of water resources [2–4]. The environmental benefits that result from adequate wastewater management make it a common practice in developed countries and an aspiration for developing countries [5–7]. In the European Union, this essential life resource is protected by community, state, regional, and local legal systems. There is extensive regulation on the use of water resources and discharges to them, as well as the parameters of the quality of treated wastewater [8]. This regulation is developed under Directive 91/271/EEC on the treatment of urban wastewater and Water Framework Directive 2000/60/EC (WFD), and approved under the principle of cost recovery of water-related services. It includes the environmental cost associated with the negative impact on the resource in accordance with the "polluter pays" principle. The adoption of European regulation has influenced the standards of different countries, involving an improvement of wastewater management, in addition to water protection and pollution reduction policies within each member state [9,10] and breakthroughs in the development of wastewater treatment technologies [11].

In Spain, Local Government Regulatory Law 7/1985 places sewage and wastewater treatment services under the jurisdiction of town councils, as local public administrations. Since the enactment of European legislation on wastewater, there have been modifications to various taxes in Spain, such as sewerage and wastewater treatment fees. The tax instruments are used to fund these specific services, which are provided by the local administration. At the same time, the sanitation fees, which are established and managed by the regional authorities, contribute to the required investment in the facilities. An additional tax, the discharge fees, which come under the jurisdiction of basin organizations, goes towards financing the study, monitoring, protection, and improvement of the receiving environment, with the aim of promoting the environmental quality of water resources. All these taxes are needed to generate the economic resources required to finance the investment in wastewater treatment plants (WWTP) and the costs of operating and maintaining them, and to improve the environmental quality of water resources [12,13]. Regardless of the requirements set out in the European legislation, suitable treatments should be selected according to the end use for the treated wastewater: discharge or reuse [14]. Tertiary treatments, which have been incorporated into wastewater treatment plant facilities over the last decade, are essential for wastewater reclamation [15]. They positively contribute to the care of the environment and have a smaller impact on total toxicity and the eutrophication of freshwater compared to direct discharges from WWTP [16].

The objective of this study is to analyse the tax collection capacity of wastewater discharges applied in Spain to finance secondary treatments, which are mandatory according to Directives 91/271/EEC and 2000/60/EC, and tertiary treatments, which are essential for the conservation of the environment and, where appropriate, the reuse of the water, to reduce the significant water deficit of this country. Depending on the applied tertiary treatment, two possible purposes are identified: environmental, through the removal of microcontaminants; and reuse, through disinfection treatments. It should be borne in mind that the aim of this research is not to determine the economic efficiency of the management of the wastewater treatment system in Spain in 2014. On the contrary, based on the latest statistical data published on amounts collected by sewage and wastewater treatment [17], the objective is to evaluate the effectiveness of a tax scheme linked to wastewater, which remains constant over time and is only updated annually using the consumer price index. This is a system largely controlled by local politicians, who in many cases do not act on the basis of economic rationality, sometimes resulting in flawed outcomes. This paper attempts to shed some light on the inconsistencies in a not very transparent practice, which give rise to irrational situations like having a WWTP, financed with resources from regional and/or supra regional institutions, which is not in operation because the local authorities do not collect enough to cover its management costs.

## 2. Materials and Methods

The statistical information needed to carry out this research comes from very diverse sources, which we detail in the following sections. All data refer to the year 2014, as it is the last year with available data on the amounts charged to users for sanitation and treatment services.

The statistics on revenues collected in Spain for sanitation and treatment come from the Spanish National Institute of Statistics (INE) [17]. They are average values for each region and include the amounts charged to users for the following items: (i) sewerage service, (ii) wastewater treatment, and (iii) ecological taxes charged by different institutions. The latter include the sanitation fee established by the relevant regional authority to cover the construction and maintenance of WWTP. They also include the taxes for discharging treated wastewater into the Public Water Resources (discharge control fee set by the Hydrographic Confederations or, if applicable, the discharge fee established by the Autonomous Communities). Of the total amount collected, 50% is allocated to financing the treatments, as specified in Section 2.1.

The costs of treatment have been estimated from the results obtained in different empirical investigations, carried out in different years and countries, published in scientific articles. The average annual cost of operating, maintaining, and investing (amortizations) in a WWTP is calculated, considering the three most commonly-used secondary treatments and the specific tertiary treatments to be analysed. In all cases, the costs used correspond to those of urban wastewater. For the sake of comparability, variables are quantified in standardized units, with all values presented in euros. To do so, the official exchange rate between the corresponding currency and the euro in the year of the empirical research of the sources has been used. The exchange rate is the one published by the World Bank for each year [18]. Likewise, all data on costs have been updated to 2014, using the INE consumer price index [19]. It should be noted that the data used for this variable are estimates, which leads to biased measures of the real situation. The specific method is detailed in Section 2.2.

The measurement of financial capacity is based on the comparison of revenues and treatment costs. The revenue collected should cover the costs of the procedure, or at least the compulsory secondary treatments. In addition, to alleviate water stress and for environmental purposes, they should also be able to finance tertiary treatments. To determine the financial capacity, the following estimate has been made:

$$Financial\ capacity = \frac{Revenues\ collected}{Treatment\ costs} \times 100 \quad (1)$$

The regions are considered to have financial capacity when the revenues cover all the costs, with a value equal or superior to 100.

### 2.1. Collection of Taxes for Wastewater Treatment in Spain

The total collection due to sanitation and treatment taxes is calculated as the quotient between the total amount paid for wastewater treatment, sanitation, and discharge fees and the volume of water registered and distributed to users [17,20]. The average revenue of sanitation and treatment in Spain was 0.72 €/m$^3$ in 2014, an increase of 5% compared to the previous year. By Autonomous Communities, the data are highly heterogeneous, with the maximum value collected being more than three times that of the minimum. The highest revenue is from the Balearic Islands and Catalonia, whereas the lowest is from the Canary Islands, Galicia, and Castile and Leon. The amount collected includes different items, which are necessary to determine for allocating funding to each service [21]. The average revenues applicable to sanitation have been estimated from the information on average taxes collected for the services of the integral water cycle [22], resulting in a percentage available for purification of 50% of the total revenues from sanitation and treatment taxes. The amounts associated with sanitation and treatment costs in the different Spanish regions are presented in Table 1.

**Table 1.** Average values collected by sanitation and treatment in the different regions of Spain in 2014.

| Region | Invoiced Amount (€) | Revenues (€/m$^3$) | Estimated Revenues (€/m$^3$) |
|---|---|---|---|
| Andalusia | 418,635,000 | 0.750 | 0.375 |
| Aragon | 73,280,000 | 0.760 | 0.380 |
| Asturias | 56,517,000 | 0.720 | 0.360 |
| Balearic Islands | 95.166,000 | 1.110 | 0.555 |
| Canary Islands | 53,816,000 | 0.370 | 0.185 |
| Cantabria | 36,131,000 | 0.750 | 0.375 |
| Castile and Leon | 94,668,000 | 0.410 | 0.201 |
| Castile-La Mancha | 67,524,000 | 0.460 | 0.230 |
| Catalonia | 610,906,000 | 1.340 | 0.670 |
| Valencian Community | 328,752,000 | 0.860 | 0.430 |
| Estremadura | 35,030,000 | 0.520 | 0.173 |
| Galicia | 81,438,000 | 0.440 | 0.220 |
| Community of Madrid | 311,654,000 | 0.770 | 0.385 |
| Murcia | 89,750,000 | 0.890 | 0.445 |
| Navarre | 32,266,000 | 0.670 | 0.335 |

**Table 1.** *Cont.*

| Region | Invoiced Amount (€) | Revenues (€/m$^3$) | Estimated Revenues (€/m$^3$) |
|---|---|---|---|
| Basque Country | 132,930,000 | 0.910 | 0.455 |
| La Rioja | 13,262,000 | 0.600 | 0.300 |
| Ceuta and Melilla | 5,073,000 | 0.580 | 0.290 |
| Maximum | 610,906,000 | 1.340 | 0.670 |
| Minimum | 5,073,000 | 0.370 | 0.173 |
| Average Aut. Communities | 140,933,222 | 0.720 | 0.360 |

Sources: [17,20–22].

### 2.2. Costs of Wastewater Treatment Technologies

#### 2.2.1. Cost of Operating a WWTP with Secondary Treatment

The average operating cost in €/m$^3$ of a WWTP has been studied starting from research that analysed the costs of 22 WWTPs of the Valencian Community, conducting an empirical application of cost-benefit analysis in the field of wastewater treatment [6]. Also, it has been analysed via a study that reports on the costs of the Sanchonuño WWTP in Segovia, Spain [23]. As a result, the following average costs were decomposed by item: energy (0.088 €/m$^3$), personnel (0.053 €/m$^3$), chemicals (0.009 €/m$^3$), maintenance (0.010 €/m$^3$), and waste management and miscellaneous costs (0.033 €/m$^3$), with the total average cost being 0.193 €/m$^3$.

Next, the operating and maintenance costs of the most commonly used secondary treatments have been estimated from a study that analysed 341 WWTPs of the Valencian Community, developing a model that includes variables such as the removal of pollutants and the age of the installations [24]. The treatments studied are activated sludge and prolonged aeration, with activated sludge accounting for 96% of the total wastewater treatment volume. Prolonged aeration, with SS solids removal efficiency levels, a chemical oxygen demand (COD), and biological oxygen demand (BOD), has removal efficiencies between 90.1% and 94.3%. Active sludge without nutrient removal, with SS, COD, and BOD, has removal efficiencies between 90.3% and 93.4%. Active sludge with nutrient removal has removal efficiencies of SS, COD, and BOD of 91.4%, and N and P of between 63.7% and 65.4% [24].

In addition, the investment costs have been estimated at 47% of the total cost, considering a study that compared wastewater treatment costs (in Germany) [25], and another that analysed the construction costs of 55 municipal WWTPs (in Israel) [26]. The average operating costs are shown in Table 2.

**Table 2.** Costs of secondary treatments updated to 2014.

| Treatment | Operating Cost and Maintenance (€/m$^3$) | Investment Cost (€/m$^3$) | Total Financial Cost (€/m$^3$) | Source |
|---|---|---|---|---|
| Active sludge without nutrient removal | 0.199 | 0.176 * | 0.375 | [18,24–26] |
| Active sludge with nutrient removal | 0.272 | 0.242 * | 0.515 | [18,24–26] |
| Prolonged aeration | 0.375 | 0.335 * | 0.711 | [18,24–26] |

Note: * Estimated cost at 47% of the total cost, considering [25,26]. Sources: [6,18,23–26].

#### 2.2.2. Average Cost of Tertiary Treatments

The average costs of tertiary treatments have been estimated from a compendium of research. First, we start with a study that developed a theoretical methodology to evaluate the internal and external economic impacts, applied to 13 WWTPs of the Valencian Community that reuse effluents for environmental purposes. This study contains reuse costs, estimating investment costs, and amortizations in 47% of total costs [27]. Second, we have used an article that conducted a study on the cost of six tertiary treatments (in some areas of the United States) that includes operating costs, infrastructure, and the commissioning of several tertiary treatments [28].

Ozonation treatment costs have been estimated from research that includes an economic perspective of this treatment and new treatments in development such as solar photocatalysis, containing the investment and operational costs (Almería, Spain) [29]. The costs of $UVH_2O_2$ have been studied from a paper that examines the operating costs for the disposal of 22 selected microcontaminants in an effluent from a municipal WWTP (Lausanne, Switzerland) [30]. UV costs have been taken from a comparative analysis of the economic costs and the quality of effluents obtained from an article that researched physico-chemical-UV ultrafiltration and microfiltration as the tertiary treatment of municipal wastewater in the urban WWTP (in Melilla, Spain) [31]. Last, chlorination costs have been obtained from research that investigated the inactivation of two antibiotic resistance genes by chlorination, ultraviolet (UV), and ozonation disinfection, including costs (in Nanjing, China), providing the costs of chlorination, UV-chlorination, and the Fenton process [32].

Table 3 shows the costs of tertiary treatment of microcontaminant disposal, with environmental objectives, and the costs of tertiary disinfection treatments, with wastewater reuse targets.

**Table 3.** Cost of tertiary treatments with environmental and reuse objectives updated to 2014.

| Aim | Treatment | Operation & Maintenance Cost (€/m$^3$) | Investment Cost (€/m$^3$) | Total Financial Cost (€/m$^3$) | Source |
|---|---|---|---|---|---|
| Tertiary treatment of microcontaminant removal | Ozonation | 0.287 | 0.267 | 0.554 | [18,27,29] |
| | UV $H_2O_2$ | 0.142 | 0.105 * | 0.247 | [18,19,27,30] |
| Tertiary disinfection treatment | UV | 0.048 | 0.045 | 0.093 | [18,27,31] |
| | Chlorination | 0.005 | 0.004 * | 0.009 | [18,19,27,32] |

Note: * Estimated cost at 47%, considering the study by [27], and the remaining treatments shown in the table, for which the investment and amortization costs represent between 42% and 48% of the total cost. Sources: [18,19,27–32].

## 3. Results

The information included in Table 4 shows the financing capacity by region and treatment. A value equal to 100 means that the revenues collected cover 100% of the costs, while a value higher than 100 means that there is a surplus after financing the total costs. A value below 100 indicates that the financing capacity is insufficient.

**Table 4.** Financing capacity of different treatments in the Spanish regions in 2014 (%).

| Region | AS | AS & Oz | AS & $UVH_2O_2$ | AS & Ch | AS & UV |
|---|---|---|---|---|---|
| Andalusia | 100.00 | 40.37 | 60.29 | 97.66 | 80.13 |
| Aragon | 101.33 | 40.90 | 61.09 | 98.96 | 81.20 |
| Asturias | 96.00 | 38.75 | 57.88 | 93.75 | 76.92 |
| Balearic Islands | 148.00 | 59.74 | 89.23 | 144.53 | 118.59 |
| Canary Islands | 49.33 | 19.91 | 29.74 | 48.18 | 39.53 |
| Cantabria | 100.00 | 40.37 | 60.29 | 97.66 | 80.13 |
| Castile and Leon | 53.60 | 21.64 | 32.32 | 52.34 | 42.95 |
| Castile-La Mancha | 61.33 | 24.76 | 36.98 | 59.90 | 49.15 |
| Catalonia | 178.67 | 72.12 | 107.72 | 174.48 | 143.16 |
| Valencian Community | 114.67 | 46.29 | 69.13 | 111.98 | 91.88 |
| Extremadura | 46.13 | 18.62 | 27.81 | 45.05 | 36.97 |
| Galicia | 58.67 | 23.68 | 35.37 | 57.29 | 47.01 |
| Community of Madrid | 102.67 | 41.44 | 61.90 | 100.26 | 82.26 |
| Murcia | 118.67 | 47.90 | 71.54 | 115.89 | 95.09 |
| Navarre | 89.33 | 36.06 | 53.86 | 87.24 | 71.58 |
| Basque Country | 121.33 | 48.98 | 73.15 | 118.49 | 97.22 |
| La Rioja | 80.00 | 32.29 | 48.23 | 78.13 | 64.10 |
| Ceuta and Melilla | 77.33 | 31.22 | 46.62 | 75.52 | 61.97 |

Note: AS: Active Sludge / Oz: Ozonization / Ch: Chlorination. Source: [17–31]. Own elaboration.

The rates and taxes for wastewater discharges must be collected in an amount sufficient to cover secondary purification treatments, currently mandatory, as established in Article 9.1 of the WFD incorporated into Spanish legislation by Article 111 bis of the consolidated text of the Law (RDL1/2001), together with the Regulation (RD 849/1986) of the Public Water Domain and Law 8/1989 of Public Rates and Prices. Activated sludge without nutrient removal is the most commercially available secondary treatment, being chosen for this analysis based on economic, environmental, and efficiency criteria [14]. In some cases, the economic instruments applied make it possible to recover costs, with a significant difference in Catalonia and the Balearic Islands. In fact, in these two cases plus the Valencian Community, Murcia, and the Basque Country, revenues exceed the costs of activated sludge treatment by more than 10%. In Andalusia, Aragon, Cantabria, and Community of Madrid, the treatment can be covered without surplus. However, Asturias, the Canaries, Castile and Leon, Castile-La Mancha, Extremadura, Galicia, Navarre, La Rioja, and Ceuta and Melilla are not able to cover treatment costs with collection.

Additional expenditure on tertiary treatments would be required if collected revenues are not enough. Two tertiary treatments with a microcontaminant removal objective have been considered, UV-$H_2O_2$ and ozonation. As demonstrated by the information in Table 4, columns 2 and 3, with the exception of UV-$H_2O_2$ in Catalonia, none of the regions would have a sufficient financial capacity to cover the costs of these treatments.

Microcontaminant removal is desirable for treated wastewater discharge into natural water bodies with environmental purposes. Nonetheless, in regions with hydric deficit, wastewater reuse for irrigation is becoming a requirement. To this end, wastewater disinfection is necessary and tertiary treatments are implemented. Columns 4 and 5 in Table 4 show the association between revenue collected and total costs, including secondary and tertiary treatments suitable for the reuse of wastewater. Specifically, chlorination and UV treatments were examined; these treatments are the most commonly chosen for water disinfection due to various economic and environmental criteria [33]. For chlorination treatment, it is verified that twelve of the 18 Autonomous Communities could not independently finance their cost with the collection that they obtain. The Balearic Islands, Catalonia, the Valencian Community, the Community of Madrid, Murcia, and the Basque Country could finance chlorination treatment. Regarding UV, the Autonomous Communities of the Balearic Islands and Catalonia would be able to finance their costs.

## 4. Discussion

First, this paper provides a great deal of regional information confirming the high territorial heterogeneity of the tax revenues associated with wastewater discharge. The total amount collected for sanitation and purification is very different among the Autonomous Communities. The average for Spain is 0.72 €/$m^3$, which is less than the amount collected in the Communities of Andalusia, Aragon, Asturias, the Balearic Islands, Cantabria, Catalonia, the Valencian Community, Community of Madrid, Murcia, and the Basque Country. The highest collection occurs in Catalonia, with a value of 1.34 €/$m^3$, 3.62 times higher than the lowest, in the Canary Islands, with 0.37 €/$m^3$. This heterogeneity can mainly be attributed to the fact that in Spain, local and, to a lesser extent, regional authorities are the entities that have the competence to establish tax figures that, in theory, should be linked to the costs of providing wastewater and treatment services [34]. This local and regionally-based approach has allowed the heterogeneity of criteria applied by local authorities, which in many cases, are influenced by electoral opportunism, to the detriment of a homogeneous structure of control and management at the state level that guarantees the uniformity of the taxes applied across the state as a whole to fulfil the principle of self-sufficiency.

Second, the analysis carried out does not confirm the ability of the Spanish regions to finance wastewater treatment with the collection obtained from taxes on wastewater discharges. In nine cases, the amounts collected do not exceed the amount of the cost of activated sludge treatment without the removal of nutrients. Catalonia and the Balearic Islands have a greater surplus after treatment application. Also, in Andalusia, Aragon, Cantabria, the Valencian Community, Community of Madrid, Murcia, and the Basque Country, the secondary treatment can be financed. In all regions, the revenue available to finance tertiary ozonation treatment is insufficient. Catalonia is the only region that could finance UV-$H_2O_2$ treatment for effluent regeneration. In twelve regions, there is no capacity to self-finance the chlorination process despite its low cost, and only two (Balearic Islands and Catalonia) could cover UV treatment.

Overall, Spanish regions have limited financial means to cover the costs of tertiary treatments for environmental purposes, in addition to relatively few cases in which the costs of tertiary treatments suitable for reuse are covered by surpluses. From the analysis performed, it can be affirmed that in almost the entire national territory, the implementation of the processes that guarantee the objectives of complete water sanitation for environmental purposes (removal of microcontaminants) from the collection of taxes is economically unviable because it does not fulfil the principle of economic-financial balance. In general, there is no self-sufficiency for the financing of the operating and investment expenses necessary for providing a required purification service, necessitating resources external to those collected for this purpose.

The results obtained for the Balearic Islands and Catalonia, with the capacity to finance tertiary treatments for reuse, do not correspond to the percentage of WWTPs providing these required services in reality, which amounted to 59% and 60%, respectively, in 2014. This contrasts with Galicia and Ceuta and Melilla, which do not have sufficient tax revenues, but in which the percentage of WWTPs with required treatments is above the national average, amounting to 82% and 100%, respectively [35]. It is also surprising that regions with resources available to finance the regeneration process of effluents for productive uses reuse less than 5% of the total purified water, as in Catalonia, with 4.02%, the Basque Country, with 1.57%, and the Community of Madrid, with 2.37%. In contrast, the Balearic Islands, Valencia, and Murcia have higher reuse rates, at 45.49%, 59.30%, and 50.35%, respectively [17].

## 5. Conclusions

The rates and taxes on wastewater discharges are a finalist environmental burden, in accordance with the Water Framework Directive and the Directive 91/271/EEC. This paper shows, first, that despite sharing legislation, there is a high heterogeneity in the amounts collected by these taxes in Spain, which are very different between the different Autonomous Communities. In addition, the amount used to cover costs does not allow the financing of treatment in many cases. It coincides with a recovery rate cost of less than 100%, as estimated by the Ministry of Agriculture, Food, and Environment for the different basin districts of Spain [36]. The revenues from these sanitary taxes are disparate and insufficient to support tertiary treatment costs in much of the national territory. Only two regions could finance UV treatment and only six could finance chlorination, which allows water to be reused. In addition, except in Catalonia, the revenues derived from applied taxes and rates do not guarantee sufficient funds to cover the costs of tertiary treatments with environmental objectives. There is therefore an urgent need to review the taxes systems applied in Spain to ensure that sufficient revenues are obtained to cover all operating and investment costs incurred to provide sanitation services. These resources could be supplemented with special contributions from private institutions, companies, non-governmental organizations, or foundations that show a commitment to the natural environment. Such entities are aware of the deterioration of the water environment caused by human activity and the need to make an effort to ensure that used water is returned to the environment in the best possible quality conditions. Similarly, it is appropriate to consider not only the financial equilibrium argument, but also the reasons for economic rationality, resource conservation, and environmental protection, as required by the WFD. The tax charges on effluent discharges must also comply with a principle of homogeneity between regions to avoid different tax costs for the same taxable event, depending on its location within the national territory.

Wastewater treatment processes are an essential element of efficient water cycle management, becoming very important in Spain because of the high level of water stress that it has, with water scarcity levels of 40% to 80% with respect to demand [37]. The recovery and reuse of effluent discharges, as a valuable and sustainable resource, require creating an environment that is conducive to change. This means that Spanish society must be made aware of the financial requirements and, above all, the implementation of specific, coordinated, and transparent actions by the competent public administrations, at local, regional, and state levels, to transform the problem of the disposal of effluents generated in urban centres into an opportunity for economic development, as defended by the UN [38].

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