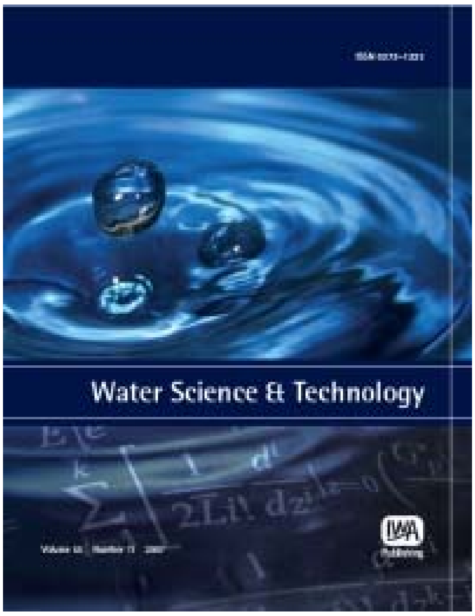
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Heterogeneity of the environmental regulation of industrial wastewater: European wineries

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ABSTRACT

The European legislation of the pollution of industrial wastewater shows a high degree of heterogeneity. This fact implies that there is a market failure with relevant consequences. Within the European Union, each Member State performs a specific transposition of the Water Framework Directive 2000/60. The member states introduce different sanitation fees to correct water pollution. In this paper, the case of the European wine industry is analyzed. It studies the sanitation fees of the five major wine producing countries: France, Italy, Spain, Germany and Portugal. Results show significant differences among the wastewater fees and the study reveals how such heterogeneity leads to relevant market distortions. The research concludes that more homogeneous environmental regulation would promote more sustainable wine production processes with more efficient water management and purification systems, as well as the introduction of cutting edge technologies.

Key words | environmental regulation, European Union, wastewater, wineries

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INTRODUCTION

The environmental concern of industrialized countries has led them to launch corrective measures in order to repair the already caused damages, as well as to remove, or partly reduce, the negative environmental effects of industrial activities. As far as water pollution is concerned, the natural water cycle has a great capacity for purification. For this reason, as well as for the apparent water abundance, water flows have become the usual dumping site for industry. Pesticides, waste, heavy metals, radioactive residues, among others, are found when water from remote places of the earth is analyzed. Water is polluted up to the point that water could be dangerous for human health and detrimental for life (Echarri 2007).

From an economic point of view, pollution is understood as a negative externality or as a market failure, which provokes the loss of a welfare agent. This kind of pollution, understood as a market failure, means an environmental problem that justifies public intervention (Román-Sánchez & Belmonte-Ureña 2013). In Europe this intervention is executed by environmental legislation introduced by each Member State, as a transposition of Community rules. Such regulations concern mainly the maximum limit of emissions but they also rule the technological process of products or consumption. Furthermore, we can find economic instruments of environmental policies such as fees and transferable rights of pollution (Gago & Labandeira 1999).

At the European level, the regulatory framework starts with the water framework directive (WFD) (Directive 2000/60/EC). Article 4 of WFD deals with the environmental objectives for surface water and the need for measures which progressively reduce pollution. Based on this directive, the member states have developed and applied their corresponding environmental fees in order to discourage polluting discharges (Freni *et al.* 2010). The specific taxation measures of each country are the sanitation fees. They generate, in turn, an income for the public or private entity for water treatment and sanitation. The generated income is devoted to financing the building, management and exploitation of the water drainage, treatment and depuration systems. In practice, the current structure of the fees relies on a declaration submitted by the industry regarding its polluting discharge. The taxation debt is calculated based on the assessment of the environmental damage of each taxpayer and their water consumption. In this sense, the sanitation tax should be understood as an industry

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incentive for an efficient use of water in quantitative and qualitative terms (Gispert 2000).

This work aims to show the heterogeneity regarding the environmental regulations on wastewater pollution within European wineries. It also analyzes the introduced distortions into the market due to such differences. The next section describes the production process of the winemaking industry, specifically the water consumption for its activities. The sample selection is further explained. Then the environmental regulations on polluting discharges and their main impacts on the market of the main wine producing countries are analyzed. Results are also assessed and discussed. Finally, the main conclusions of this study are shown.

BACKGROUND TO THE EUROPEAN WINE INDUSTRY

The use of water by agro-food companies is critical for the development of this relevant productive activity. The use of water varies highly in this sector since water can also be used as a cooling agent in many production processes. However, clean water is essential for food security, since it is used to clean and disinfect floors, processing equipment and containers and also is used as an ingredient. This can represent up to the 70% of water use in the agro-food business (FoodDrinkEurope 2012). The consumption and availability of this resource after its use raise many technological, social, economic and environmental questions regarding sustainability. The improvement of water management systems and polluting discharges has an impact on the rationalization of associated costs (energy, consumption fee, treatment of waste and process water, etc.) and can provide relevant economic savings. Water management within this sector constitutes an element to be improved since it makes an intensive use of this resource. It is a determining factor in terms of efficiency and productivity.

Most residual waste is usually pretreated so that the target channels only receive a reduced amount of pollutants. In the case of the food industry, and especially in the case of wineries, the main problem is the liquid waste (Sekoulov 2002). At the European level, the wastes of food and agriculture industries are regulated by Directive 91/271/EEC. This directive also rules the collection and treatment of urban sewage.

Water consumption in the production of wine

Wineries, like all food processing industries, are heavily dependent on the constant supply of water, so that its treatment and recycling can be profitable (Kemp 1998). Water consumption in wineries ranges from 1 to 6 litres of water per litre of wine produced. The exact amount depends on many factors, like the type and quality of facilities and materials, cleaning processes and supply and water treatment costs. Based on previous research (Cobo & Prodanov 2003; Pizarro & Nely 2003) and taking into account that each winery follows a different model of water consumption, a standard consumption of 1.5 litres of water per litre of produced wine has been established. This value is in accordance with the sector and combines economic and legal aspects when rationalizing water consumption.

Furthermore, due to the strong irregularities of wine polluting discharges concerning time, composition and volume, it is complicated to establish a mean value of wastewater parameters within the winery sector. However, it is well known that several parameters have a direct impact on both the pollutant composition of wastewater and purification efficiency (Rajeshwari *et al.* 2000). The most common parameters are the following: the type of wine (white or red), the processes followed for the production of wine, the volume of the tanks used, production seasonality, continuity throughout the working day, variability according to the winery, content in organic material, volume of the material in suspension, acid character, presence of polyphenol and nutrient deficiencies (Vlyssides *et al.* 2005).

In any case, the industrial management of water implies three lines of actuation: firstly, savings in fresh water consumption; secondly, the purification of winery effluents and, finally, the recycling of water used in the process. Based on the assumption that fresh water consumption is optimized, the next priority should be the minimization of the winery effluents, since the lower the volume of waste, the cheaper the treatment cost. It is essential to know the main features of each winery discharges and to note where the greater volume of residual waste is produced. The main goal is to introduce mechanisms and good practices devoted to reducing the pollution volume and to increasing the recycling process.

Generally, the polluting effluents of wineries are measured by the parameters shown in Table 1. The table also shows a comparison between the winery pollutants and the domestic waste in an urban area. A great difference between domestic waste and winery polluting effluents is observed. It demonstrates the need for using an independent purification system in the wine industry, since the wastewater treatment plants are not equipped to deal with waste with such values. In the worst case, the urban water

Table 1 | Pollution parameters by type of discharge

Pollution parameter	Quantity in the winery effluent	Quantity in urban wastewater
BOD_5	3,000–15,000 mg/l	<350 mg/l
COD	5,000–25,000 mg/l	500–700 mg/l
SS	1,000–6,000 mg/l	150–300 mg/l
C	1,000–2,000 S/cm	>2,000 S/cm
pH	4–5	–

Source: Personal compilation based on Life Sinergia (2012).

treatment plants which cannot cope with winery wastewater could consequently also fail in purifying the domestic waste.

For this reason, in order to assess the treatment of wastewater from the wine industry it is necessary to take into account the cost of introducing a purification system. When an efficient and usually more expensive water treatment plant is running according to the current legislation, a higher degree of water purification is achieved and the environmental fees can be consequently reduced. A purification optimum is to be found to keep the effluent treatment cost and the sanitation fee as low as possible. At the same time, wine producers should be oriented to a greater recycling system.

Sample selection

European wine production is concentrated in five countries (Italy, Spain, France, Germany and Portugal). They account for 88.7% of the total wine production in the European Union (Table 2). Nevertheless, when comparing wine qualities we see that country relevance varies. France produces 19.9 million hectoliters of wine per year and was the first wine producer with Protected Designation of Origin in Europe. In contrast, Italy produces 16.2 and Spain 14.8 million hectolitres.

Table 2 | European production of wine and grape-juice (2012/2013)

Country (data in thousands of hl)	2012/2013	% s/total
Italy	46,500	27.2
Spain	45,500	26.6
France	44,100	25.8
Germany	9,011	5.3
Portugal	6,740	3.9
Rest of EU	19,249	11.3
EU total	171,100	100.0

Source: International Organization of Vineyard & Wine – IOV (2013).

The comparison of the environmental legislation of the top five wine producing countries is focused on wine production with Protected Designation of Origin. In the study, five wines with Protected Designation of Origin are compared, since they have common quality standards, competition level and trading volumes. The Designations of Origin are the following ones:

- Wine made from Riesling grapes, corresponding to a region of Rhine (Germany).
- Rioja Wine, corresponding to the region of Rioja (Spain).
- Bordeaux Wine, corresponding to the region of Aquitaine (France).
- Wine of Tuscany, corresponding to a region of Florence (Italy).
- Wine of the Douro, corresponding to a region of Oporto (Portugal).

COMPARISON AND DISCUSSION OF EUROPEAN SANITATION FEES

European environmental legislation has fostered the minimization of pollutants in industry wastewater. The imposed fees do not have the sole purpose of collecting funds: they also promote more sustainable policies in the production process (Lema & Omil 2001).

From a fiscal point of view, pollution is considered a negative externality, namely a market failure that prevents proper allocation of resources in the market. In this sense, environmental legislation emerges as a corrective agent of environmental externalities. The goal is to impose a price for polluting in the form of sanitation fees. These fees also discourage pollution and serve as a means of collecting public funds for the administration to finance environmentally sustainable policies. The fees should be as effective at reducing the cost of environmental policies. At the same time, they have to promote technological developments and a sustainable culture within the industry, especially in the agri-food area (Crabtree & Morris 2002).

However, certain heterogeneity in the regulation of polluting discharges and sanitation fees can be found in the European Union. In order to show this heterogeneity and its consequences, the sanitation fees of the top five wine producing countries in Europe have been analyzed.

It is necessary to note that the sanitation fee is a local or regional tax, which can vary according to the region in a same country, except for Germany, where they are applied at a national level. Generally, the fee structure is made up of two terms. The first is a fixed cost regardless of the winery discharge volume. The second is variable and depends on the discharge volume of wastewater and its level of pollution, i.e. the polluting load.

The fee to be paid is the result of multiplying the polluting load of the discharge and units of pollution by the assigned value to the unit (Table 3). In this way, the taxable base is expressed in units of pollution and the tax rate in euros per unit of pollution

$$I = V \cdot P_U$$

where:

I Total sanitation fee

V Discharge volume

P_U Price per unit

In order to characterize the pollution of wastewater, different parameters are used such as the chemical oxygen demand (COD), the presence of suspended solids (SS), conductivity (C), the biological oxygen demand (BOD), the concentration of nutrients, mainly nitrogen (N) and phosphorus (P), heavy metals (HM), inhibitory substances (IS) and the difference of temperature (ΔT).

Table 4 shows the parameters to be considered in the fee calculation for each selected region. For instance, COD is considered in all regions, while the C only appears in the calculation of the Spanish tax. The second most relevant parameter corresponds to SS, included in all cases except for Germany.

Table 3 | Sanitation fee according to the European region

Region/Country	Tax base of sanitation fee	Observations
Aquitaine, France (a)	$Fee_{Aquitania}$ (€/year) = [(BOD·0.149) + (COD·0.074) + (SS·0.119) + (P·0.4)]·Q_w + (SR + TR)·Q_w	SR = 0.012 TR = 0.23
Florence, Italy (b)	$Fee_{Florence}$ (€/year) = FC + (SR + TR)·Q_w + I_{COD} + I_{SS} + I_N + I_P FC (€/year) = 15,000 I_{SS} = 0.35·(SS−0.2)·Q_w I_N = 2.5·(N−0.03)·Q_w I_P = 3.5·(P−0.01)·Q_w I_{COD} = 0.35·C_{COD}·(COD−0.5)·Q_w	FC = fixed cost SR (€/m^3) = 0.18 TR (€/m^3) = 0.33 I_{COD}, I_{SS}, I_N, I_P pollution coefficients applied if: S > 0.20 (kg/m^3) N > 0.03 (kg/m^3) P > 0.01 (kg/m^3) COD > 0.5 (kg/m^3) C_{COD}: COD coefficients according to COD and BOD
La Rioja, Spain (c)	Fee_{Rioja} (€/year) = 0.35·PL·Qw PL = 0.276·SS/0.22 + 0.458·COD/0.5 + 0.266·C/0.0024	Minimum value for PL is 0.35
Oporto, Portugal (d)	Fee_{Oporto} (€/year) = [a_i + (b_i·SS) + (c_i·OM) + (d_i·MIS)]·Q_w OM (kg/m^3) = [(2·BOD) + COD]/3 MIS (kg/m^3) = [(HM·5) + (As·1,000) + (CN·50) + (Phe·1.25) + (HC·1)]	a_i: constant relative to flow, €/m^3 b_i: constant relative to total SS, €/kg c_i: constant relative to total oxidizable materials, €/kg d_i: constant relative to the mixture of inhibitory substance, €/kg As: arsenic kg/m^3 CN: cyanide kg/m^3 Phe: phenol kg/m^3 HC: hydrocarbons kg/m^3
Rhine, Germany (e)	Fee_{Rhine} (€/year) = [SE_{COD} + SE_N + SE_P]·35.79 $SE_{COD} = \frac{COD \cdot Qw}{50}$ $SE_N = \frac{N \cdot Q_w}{25}$ $SE_P = \frac{P \cdot Q_w}{3}$	SE = pollution units Specific pollution load rate in €/kg is 35.79

Source: Personal compilation based on the legislation:
(a) Agence de l'Eau Adour-Garonne 2012.
(b) Board of Directors Regulations Service 2010.
(c) Boletín Oficial del Estado 2000.
(d) Regulamento de Descarga de Águas Residuais Industriais 1998.
(e) Gesetz über Abgaben für das Einleiten von Abwasser in Gewässer 2010.
See Table AI in Appendix for nomenclature (available online at http://www.iwaponline.com/wst/072/387.pdf).

Table 4 | Pollution parameters in the European Union fees

	Pollution parameter					
Country, region	**COD**	**N**	**P**	**C**	**BOD**	**SS**
Germany, Rhine	x	x	x			
Spain, Rioja	x			x		x
France, Aquitania	x	x	x		x	x
Italy, Florence	x	x	x		x	x
Portugal, Oporto	x				x	x

Source: Own compilation based on the legislation of each region/country.

In short, the consideration of a parameter in the fee calculation to be paid depends on the industry features of each region. In this way, a region that is less industrialized or with a scarcely polluting industry will only include the most relevant parameters in the fee calculation. In contrast, in more industrialized areas, the sanitation fee will be more complex. It will take into account more specific parameters so that the principle 'who contaminates, pays' can be fulfilled.

Table 5 shows the mean pollution values of the winery effluents in order to compare the sanitation fee effectiveness of each region (Life Sinergia 2012). It also shows the maximum allowed parameters according to each regulation of hydraulic public domain (HPD). The latter values are used to calculate the fee to be paid since each winery, regardless of its location and wastewater, has to adjust the discharged water quality to the current legislation. In order to achieve this, the winery will have to pre-treat its discharges.

As far as the treatment of wastewater is concerned, the main objective is to remove dangerous pollutants from the environment (Choubert *et al.* 2011). Where wineries are concerned, the type and quantity of effluent pollutants are known so that the introduction of the most adequate purification system can be assessed according to their needs (Anastasiou *et al.* 2009). It is not enough to optimize the consumption of clean water: it is also necessary to carry out a comprehensive control of the winery discharge (Oliveira *et al.* 2009). According to Román Sánchez *et al.* (2011) the mean cost of the wastewater purification through a secondary biologic treatment amounts to €0.36/m^3. All wineries should therefore assume this mean cost per each m^3 of polluted water in order to discharge it in a public water domain.

To calculate the discharge volume, it should be taken into account that the production of a winery varies drastically from an area to another one. Factors like climate, water supply, type of cultivation, product quality and demand have an effect on the production volume. Considering all these factors, we have assumed a mean production of 130,000,000 litres of wine per season. And the water consumption has been fixed between 1 and 1.5 litres per litre of wine produced, so that a mean discharge effluent of 195,000,000 litres is generated. Each studied winery will therefore assume a mean cost of 70,200 euros for the primary treatment. Moreover, the corresponding sanitation fee has to be added to this amount. The addition of both will be the cost to be paid by each winery as a mean value in the studied regions (see Table 6).

As we can see in Table 6, the total discharge cost varies greatly depending on the region where the winery is located. The highest cost for treatment is paid in the region of Florence (Italy), followed by wineries located in Oporto (Portugal). In contrast, the lowest discharge effluent cost to be paid is that by wineries located in Rioja (Spain), which is only 87,052.54 euros.

Conversely, the mean value of the sanitation fee to be paid is 68,780.80 euros. The regions of Spain, France and Germany pay a lower sanitation fee, under the mean value, while Italy and Portugal pay much more. Furthermore, it is interesting to note that in the region of Aquitania (France), the sanitation fee is very close to the mean value of the five regions.

Table 5 | Pollution parameters in winery discharges: mean and maximum allowed values

Parameter	**Physicochemical parameters for winery wastewater (mean values)**	**Discharge to flow HPD**
SS (mg/l)	1,800	80
BOD_5 (mg/l)	4,500	40
COD (mg/l)	7,000	160
N (mg/l)	80	10
P (mg/l)	35	10

Source: Public Water Regulation (1986) and data from Life Sinergia (2012).

Table 6 | Total cost in euros of discharge per European region

Region, country	**Mean cost of pre-treatment**	**Sanitation fee to be paid**	**Total cost of polluting discharge**
Florence (Italy)	70,200	114,450.00	184,650.00
Oporto (Portugal)	70,200	110,763.90	180,963.90
Aquitania (France)	70,200	53,449.50	123,649.50
Rhine (Germany)	70,200	48,388.08	118,588.08
Rioja (Spain)	70,200	16,852.54	87,052.54

Source: Data calculated by authors.

CONCLUSIONS

The production of wine, like in other food industries, consumes a significant amount of clean water and generates a considerable volume of polluting effluents, which should not return untreated to the environment. Government intervention is needed to ensure the proper treatment of wastewater and to foster investment in wastewater recycling systems within wineries.

This study has shown the European heterogeneity into broken-down amounts to be paid for polluting discharges within the same industrial activity. After reviewing sanitation fees of the five major European wine producers, significant differences in the tax structure can be seen. In Italy and Portugal, wineries pay a sanitation fee above the mean value, while the wineries in Germany and Spain pay a lower one. However, the French wineries pay a sanitation fee similar to the mean value.

This work has revealed how an unequal transposition of the European Union environmental regulations on industrial wastewater treatment made by each Member State discourages the investment in improving wastewater treatment and management. Wineries in Italy and Portugal are driven towards an efficient use of fresh water and wastewater treatment in other to minimize sanitation fees and improve their market competitiveness. Conversely, Spanish wineries are more competitive in the market as a result of lower sanitation fees although investment in wastewater treatments is not favored. The European Union environmental legislation should be harmonized in order to avoid such market failures and optimize its efficiency.

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