Environmental Assessment of Reclaimed Water Production for Mediterranean Agriculture: Insights from the I-REWATER Project

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Introduction

The project aims to promote the **use of reclaimed water** in **irrigation systems** across the **SUDOE region**, reducing reliance on conventional sources and im**proving both the availability and quality of water** (I-ReWater, 2025).



Woody crops





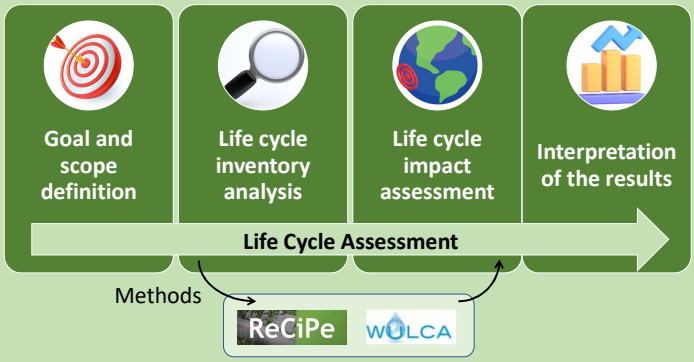
Horticultural crops

Why assess environmental impacts?

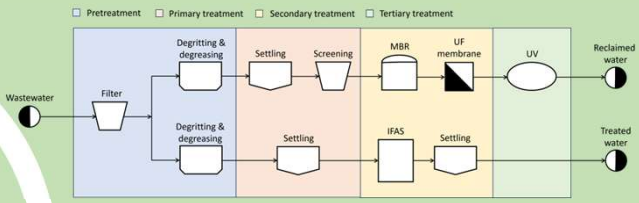
The environmental evaluation considers the **full life cycle** of **water reuse systems and crop production**, identifying **impacts** in key categories such as eutrophication, ecotoxicity or water footprint, and **highlighting the main hotspots** to support sustainable decision-making



Methodology



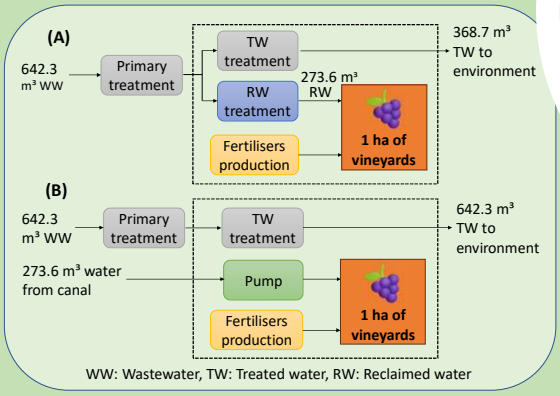
Example of wastewater treatment plant



Electricity consumption is the main environmental **hotspot**

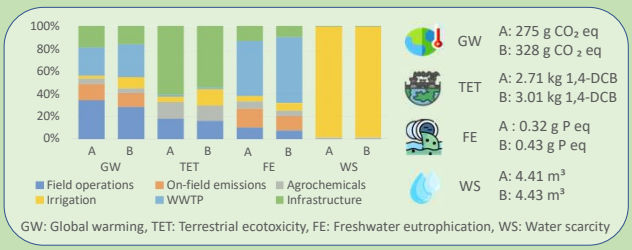
I-REWATER Project

Results: Vineyard pilot (ICVV)



FU: 1 kg of grapes

Cradle to farm-gate approach



Conclusions

- The **reclaimed water scenario** shows **better environmental performance** than the treated canal water scenario
- The **main hotspot** in both systems is the **water treatment process** itself, indicating that further technological improvements are still required
- The **viability** of reclaimed water systems is directly related to their **energy demand**; therefore, reducing energy consumption is essential

Contact me

Published papers

Vineyard ICVV | Vineyard ICVV | Technologies | Hops USC | Hops Hopen

Interreg Sudoe
Co-funded by the European Union
I-ReWater



References

- I-ReWater. (2025). *Gestión sostenible de los recursos hídricos en la agricultura de regadío en el espacio SUDOE [Sustainable management of water resources in irrigated agriculture in the SUDOE area]* [Website]. Interreg SUDOE. https://interreg-sudoe.eu/proyecto-interreg/i-rewater/

Acknowledgement: This research has been supported by the project "Sustainable management of water resources in irrigated agriculture in the SUDOE area (I-ReWater-S1/2.5/E0136)", co-funded by the programme INTERREG SUDOE. A.A.O. and S.G.G. belong to the Galician Competitive Research Group (GRC ED431C 2025/19) and to the Cross-disciplinary Research in Environmental Technologies (CRETUS Research Center, ED431G 2023/12).

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RECLAIMED WATER AND LOW-COST SENSOR NETWORKS FOR SUSTAINABLE IRRIGATION MANAGEMENT IN TEMPRANILLO RIOJA VINEYARDS

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Background



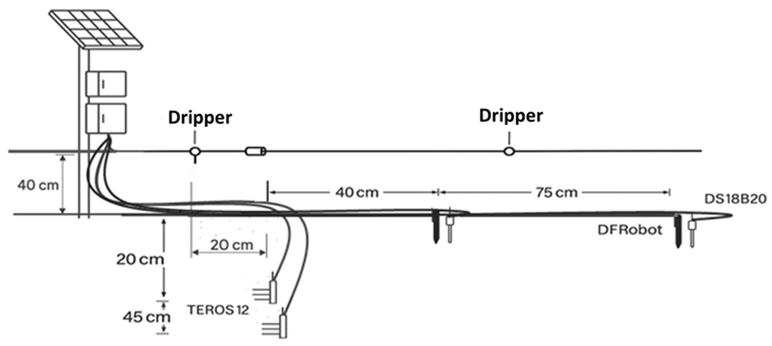
The INTERREG SUDOE I-ReWater project evaluates the use of reclaimed water for agricultural irrigation and develops low-cost sensor networks to create a Decision Support System (DSS) for small-scale farms. Within this framework, a pilot study led by the Instituto de Ciencias de la Vid y del Vino (ICVV) assessed the effects of reclaimed water irrigation in vineyards. The experiment was conducted during the 2024 and 2025 growing seasons in an organically managed vineyard located in finca La Grajera (DOCa Rioja area), planted in 2018 with Vitis vinifera L. cv. Tempranillo (2 ha; 3,000 vines/ha).

Material & Methods

Two irrigation treatments were compared: reclaimed water from the La Grajera wastewater treatment plant and conventional irrigation water from the Iregua irrigation canal. The experimental design consisted of two treatments with three rows each, monitoring 10 vines per row (60 vines total).

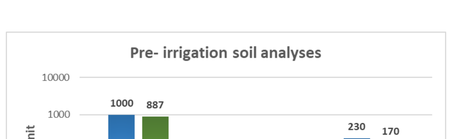
Soil quality was assessed before and after irrigation by a 30 cm depth sample. Vine nutritional status was evaluated by foliar analyses at flowering and at veraison. Irrigation water quality was monitored through physicochemical and microbiological analyses as well as phenological, yield and pruning components.

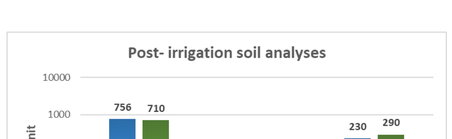
A low-cost sensor network enabled real-time monitoring of soil and microclimatic conditions, supporting irrigation scheduling and informed decision-making for the prevention of soil salinity risks.

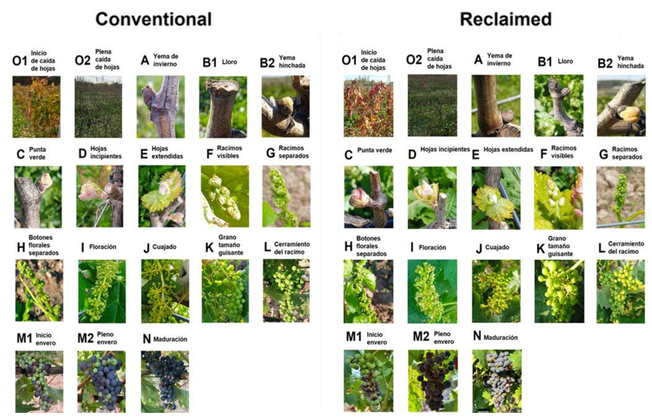


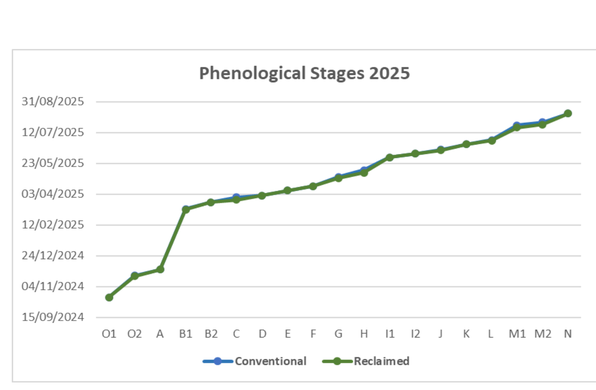
Results

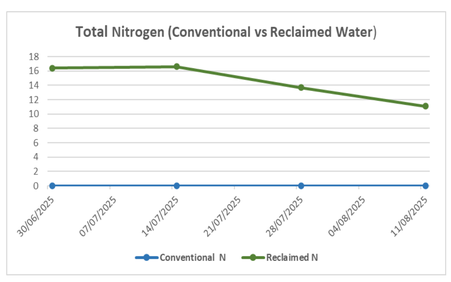
No significant differences in yield or vine vigour were observed between treatments in either season. Reclaimed water irrigation tended to increase the number of berries per cluster, and in 2025 also showed a trend toward higher 100-berry weight.

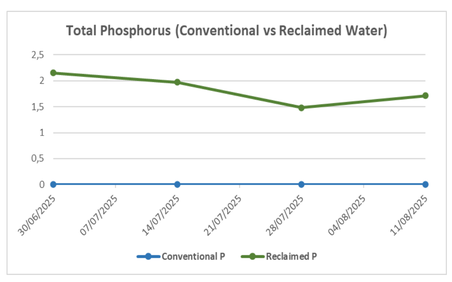


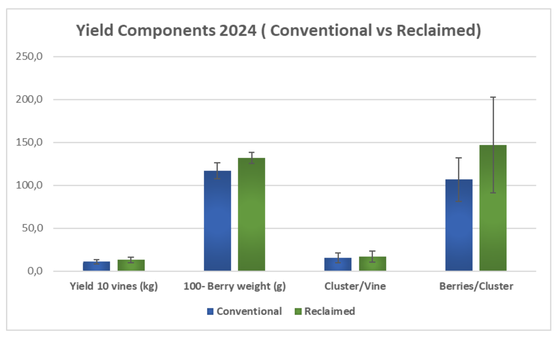


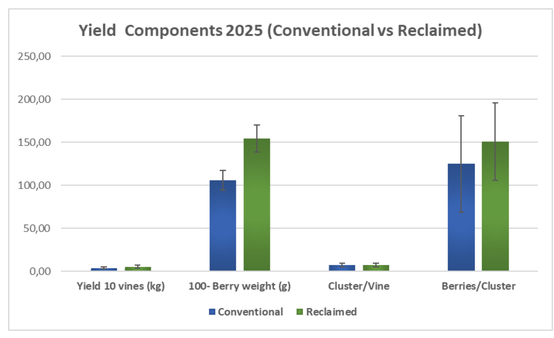




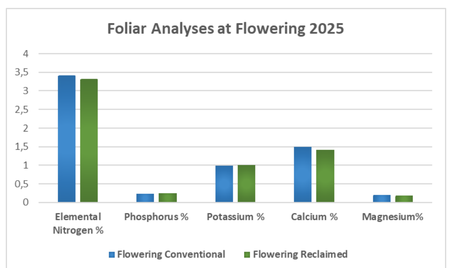


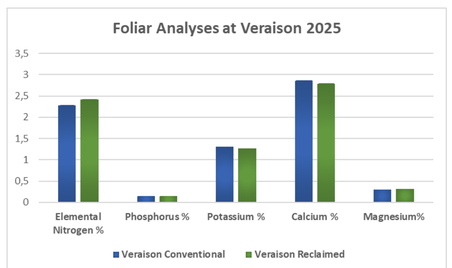




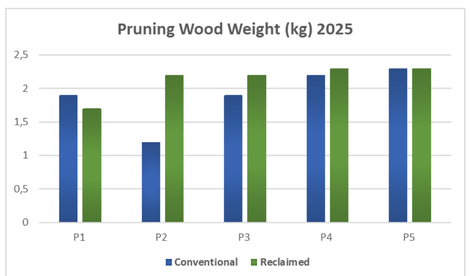


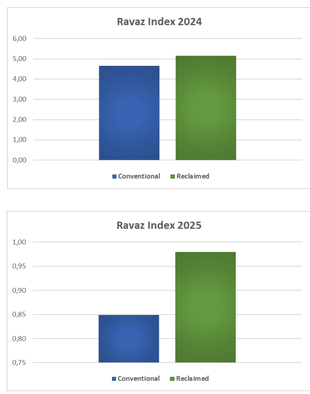
Irrigation Water	pH	E.C. (µS/cm)	COD (mg O_2/l)	N Total (mg/l)	NO_3^- (mg/l)	NH_4^+ (mg/l)	NO_2^- (mg/l)	P Total (mg/l)	S.S. (mg/l)	BOD_5 (mg O_2/l)	E. coli (NMP/100 ml)
Conventional	7,98	216,00	<10	<5	<2	<0,5	<0,02	<1	<5	<25	<1
Reclaimed	7,8	735	18,5	14,45	57,4	1,22	0,1	1,71	<5	<25	26











Conclusions

Overall, preliminary results indicate that reclaimed water represents a sustainable alternative for vineyard irrigation, with no negative short-term effects on vine performance.

Acknowledgements: Project 'Sustainable management of water resources in irrigated agriculture in the SUDOE area (I-ReWater-S1/2.5/E0136)' co-funded by the programme INTERREG SUDOE
Thanks to the Instrumental Analysis Service and the Plant Resources Service of the ICVV

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USE OF RECLAIMED WATER IN TEMPRANILLO VINEYARDS: INFLUENCE ON CHEMICAL COMPOSITION

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Background



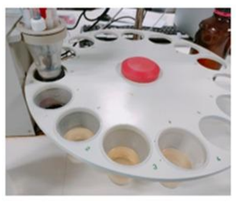
The European I-Rewater project aims to evaluate the potential use of reclaimed water for agricultural irrigation. The study was conducted in an organically managed Tempranillo vineyard planted in 2018. Two irrigation treatments were compared: reclaimed water from the La Grajera wastewater treatment plant (WWTP) and conventional irrigation water from the Iregua irrigation canal.

The study focused on the physicochemical and aromatic quality of grapes obtained using both irrigation systems, with the aim of performing a comparative analysis during the 2024 and 2025 harvest seasons.

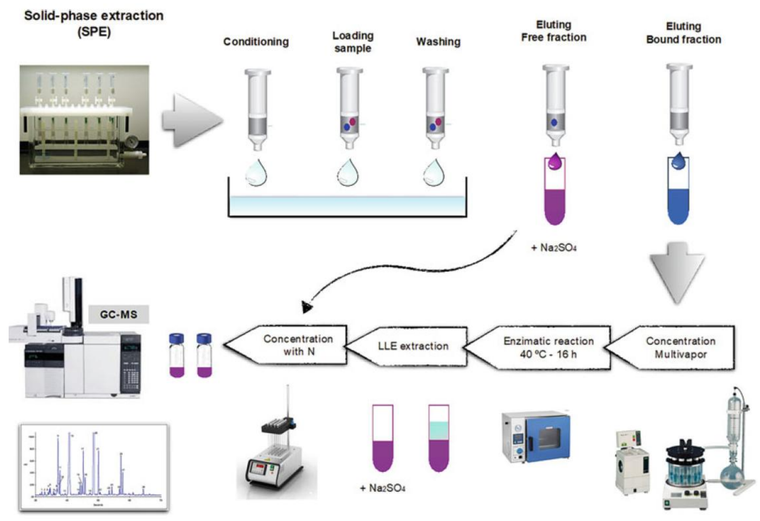
Material & Methods







Physicochemical analyses were carried out using a Biosystems SPICA multiparametric enzymatic analyser and a potentiometric titrator. The **aromatic characterization** was performed through the extraction of volatile compounds using solid-phase extraction (SPE) cartridges, followed by injection into a gas chromatography–mass spectrometry system (GC–MS).



Results









Regarding physicochemical parameters, no significant differences were observed between treatments, except for the PAN and FAN content. Grapes irrigated with reclaimed water showed a tendency toward improved nitrogen availability, exhibiting higher PAN and FAN concentrations.

In 2024, a total of 30 volatile compounds were identified and classified into eight aromatic families (C13-norisoprenoids, C6 compounds, alcohols, aldehydes, esters, lactones, fatty acids, and others). C13-norisoprenoids (associated with floral aromas), volatile fatty acids, and compounds included in the “other” family exhibited higher concentrations when reclaimed water was used for irrigation. In contrast, lactones (associated with caramel, sweet, and fruity aromas) showed higher concentrations in grapes irrigated with conventional irrigation.

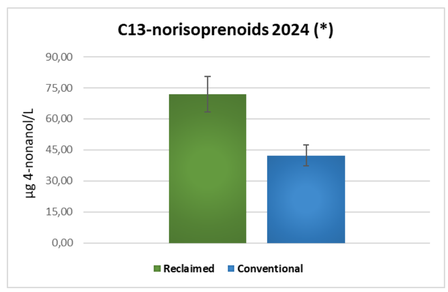
In 2025, 23 volatile compounds were analysed, and grouped into six aromatic families (C6 compounds, alcohols, fatty acids, volatile phenols, carbonyl compounds and others). Among these, only Carbonyl compounds exhibited higher concentrations in grapes irrigated with reclaimed water.

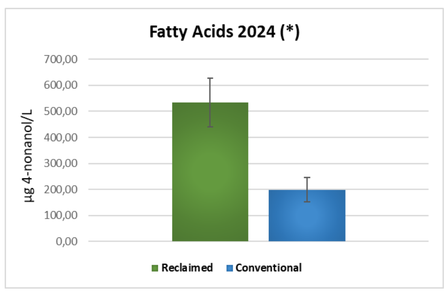
Chemical Parameters in Must 2024

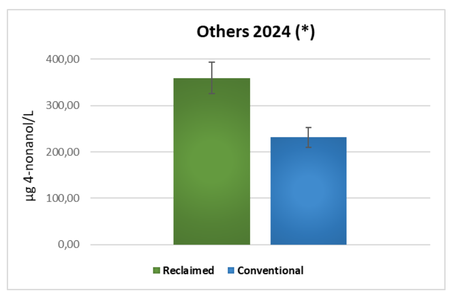
Parameter	Conventional	Reclaimed	Sig
°Brix	24,77	24,07	ns
Probable Alcohol (%)	14,67	14,18	ns
Acetic Acid (g/l)	0,03	0,07	*
Malic Acid (g/l)	2,57	2,52	ns
pH	3,77	3,76	ns
Total Acidity (g/l)	4,66	4,57	ns
Ammonium (mg/l)	57,67	44,33	ns
PAN (mg/l)	137,67	105,00	*
FAN (mg/l)	184,67	141,33	*
Gluconic Acid (g/l)	0,17	0,26	ns
TPI	25,67	22,67	ns

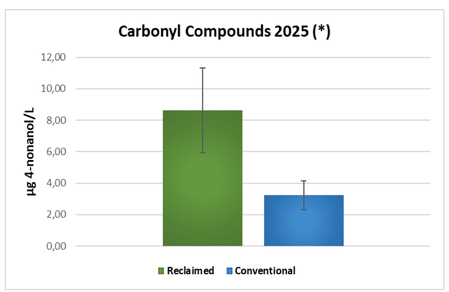
Chemical Parameters in Must 2025

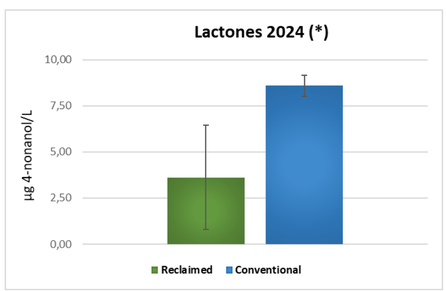
Parameter	Conventional	Reclaimed	Sig
°Brix	24,80	23,07	ns
Probable Alcohol (%)	14,70	13,50	ns
Acetic Acid (g/l)	<0,004	<0,004	ns
Malic Acid (g/l)	2,08	2,47	ns
pH	4,02	4,03	ns
Total Acidity (g/l)	3,98	4,20	ns
Ammonium (mg/l)	102,00	108,00	ns
PAN (mg/l)	192,00	222,67	*
FAN (mg/l)	275,67	311,00	*
Gluconic Acid (g/l)	0,06	0,08	ns
TPI	27,33	33,33	ns

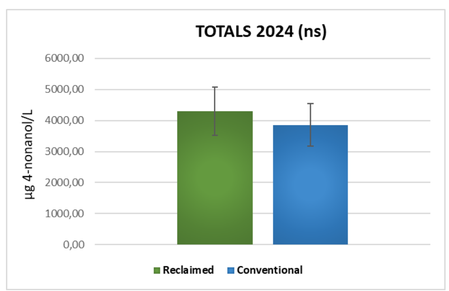


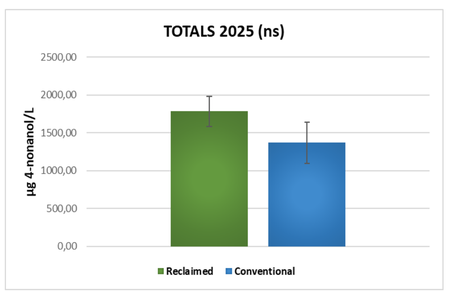












Conclusions

In conclusion, considering the overall results, no significant differences were observed in most of the analysed parameters between grapes irrigated with reclaimed water and conventional irrigation, indicating that reclaimed water is a viable alternative for vineyard irrigation without negative short-term effects on grape aromatic quality.

Acknowledgements: Project ‘Sustainable management of water resources in irrigated agriculture in the SUDOE area (I-ReWater-S1/2.5/E0136)’ co-funded by the programme INTERREG SUDOE
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IMPACT OF RECLAIMED WATER IRRIGATION ON HOP AROMATIC OIL COMPOSITION

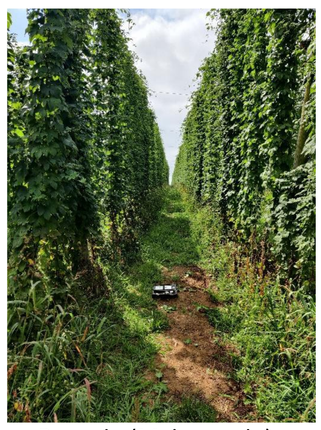
Mikel Landín Ross-Magahy[1,2], María Malia Molleda[2], Maria Fandiño Beiro[3], Javier José Cancela Barrio[3,4], Mar Vilanova de la Torre[2,4]

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[3]GI-1716, Escola Politécnica Superior de Enxeñaría, Universidade de Santiago De Compostela, Lugo, Spain
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Background



Cubillos del Sil



Presedo (Mabegondo)

The European I-ReWater project (INTERREG SUDOE) investigates the use of reclaimed water as an alternative source for hop irrigation. The study was carried out on *Humulus lupulus* L. cv. Nugget at two pilot sites in Spain: Cubillos del Sil (León), established in 2022, and Mabegondo (A Coruña), established in 2008.

At both locations, in 2024 and 2025 seasons, two treatments were evaluated: irrigation with reclaimed water supplied from a wastewater treatment plant (WWTP), and irrigation with conventional water (channel).

Material & Methods

The impact of irrigation water type on hop aromatic composition was assessed through hop oil analysis, after a steam distillation of dry cones using a Clevenger apparatus (EBC method 7.10).

Volatile compounds from hop oil were analysed following a dilution-based extraction protocol. An initial 1:200 dilution was prepared by first performing a 1:20 dilution, followed by a subsequent 100-fold dilution. To ensure accurate quantification, the exact mass corresponding to 15 µL of hop oil was determined gravimetrically. Finally, 1 µL of the prepared solution was injected into the GC–MS system for analysis.

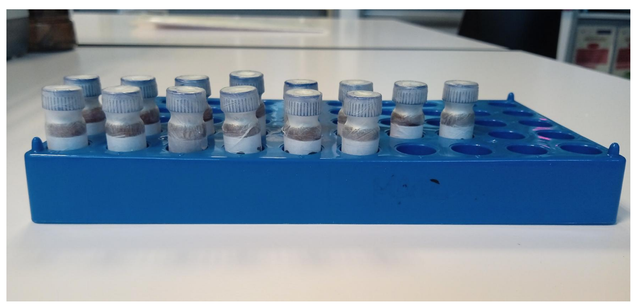




Results

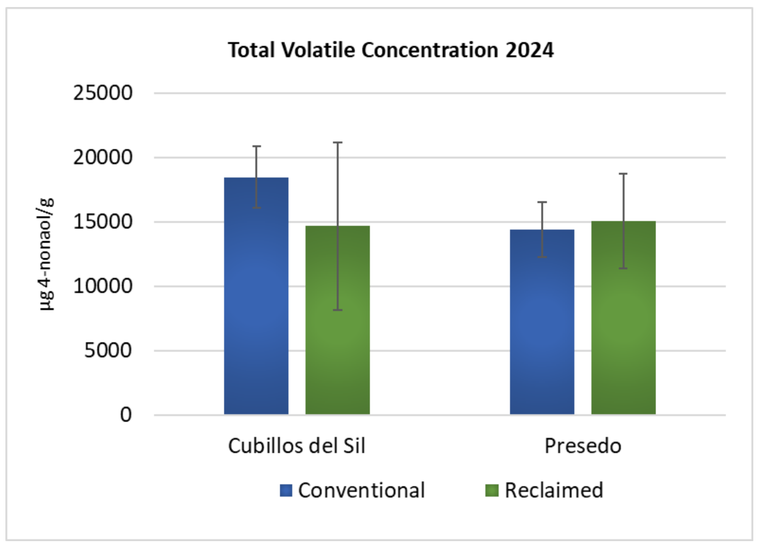
A total of 59 volatile compounds were identified and semi-quantified using gas chromatography–mass spectrometry (GC–MS). Twelve samples were analysed from the Cubillos del Sil pilot site and sixteen from the Mabegondo pilot site. No significant differences were observed in the total volatile content between irrigation treatments at either site.

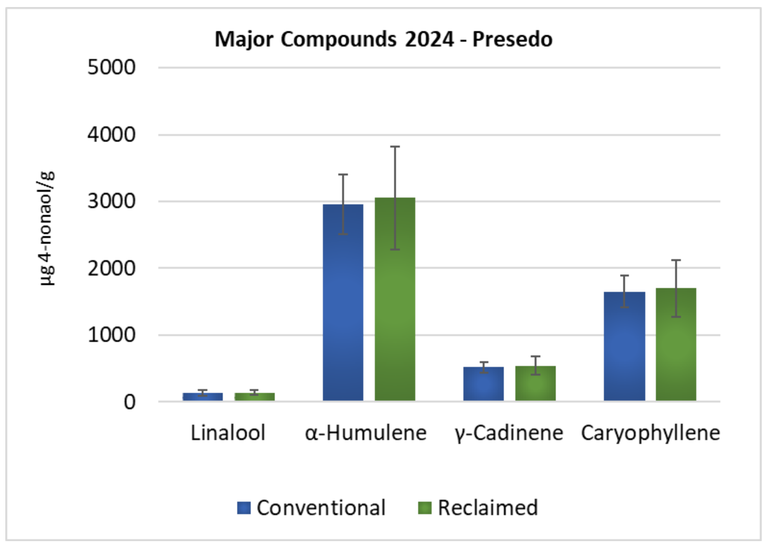
Considering the major compounds, linalool, α-humulene, ϒ-cadinene and caryophyllene, no significant differences were observed for any of them in any of the study trials, Cubillos del Sil and Mabegondo.

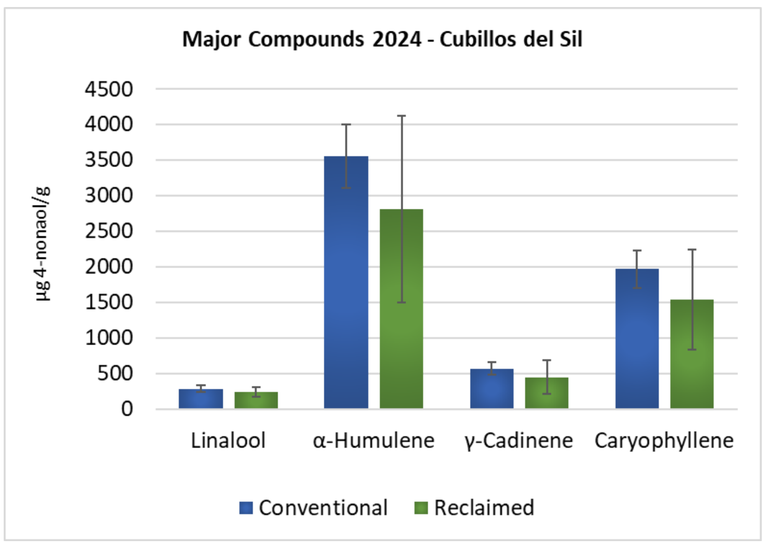












Conclusions

Overall, in the first year of study the results indicate that the use of reclaimed water for irrigation does not significantly affect the volatile profile of hops in the short term, supporting its potential application as an alternative irrigation source without adverse effects on hop aromatic quality.

Acknowledgements: Project 'Sustainable management of water resources in irrigated agriculture in the SUDOE area (I-ReWater-S1/2.5/E0136)' co-funded by the programme INTERREG SUDOE
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I-REWATER PROJECT: IRRIGATION TRIAL WITH RECLAIMED WATER IN A TOMATO ORCHARD IN CARRIÓN DE LOS CÉSPEDES (SPAIN)

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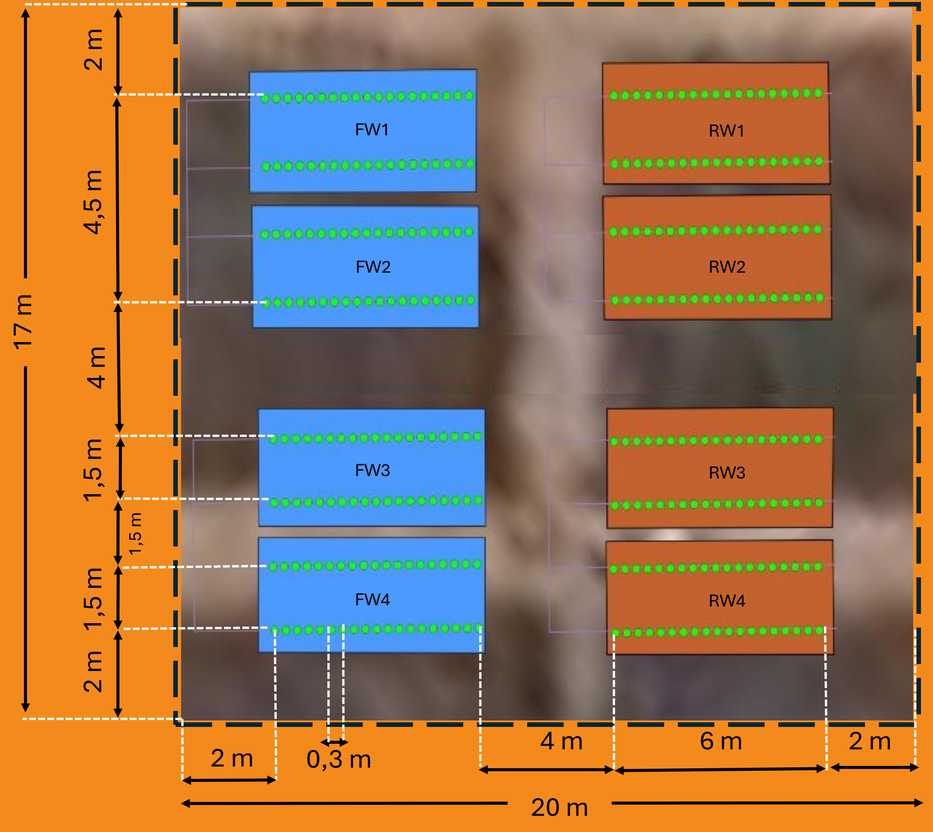
I-ReWater

1. Introduction: I-ReWater project

The I-ReWater project aims to promote the sustainable management of water resources across the SUDOE area (southern France, Spain, Portugal, and Andorra), in line with new regulations governing the use of reclaimed water for agricultural irrigation. The project includes 15 pilot actions on woody and horticultural crops, assessing the effects of reclaimed water irrigation through soil and foliar analyses, irrigation water quality monitoring, and evaluation of crop production quality.

2. Pilot study





- Carrión de los Céspedes (Seville, Spain)
- Processing tomato // var: 'H1015 (Heinz)'
- Plant spacing:1,5 x 0,3 m // loamy soil
- Drip irrigation: Emitters 1l/h // 1,5x 0,3 (1dripper/plant). Application rate: 2,22mm/h
- May to August 2025
- Experimental Design: Randomized Complete Block Design (RCBD) (2 treatments · 4 replications). FW: Irrigation water; RW Reclaimed water
- Soil analyses
- Foliar analyses
- Irrigation water quality
- Tomato quality and yield

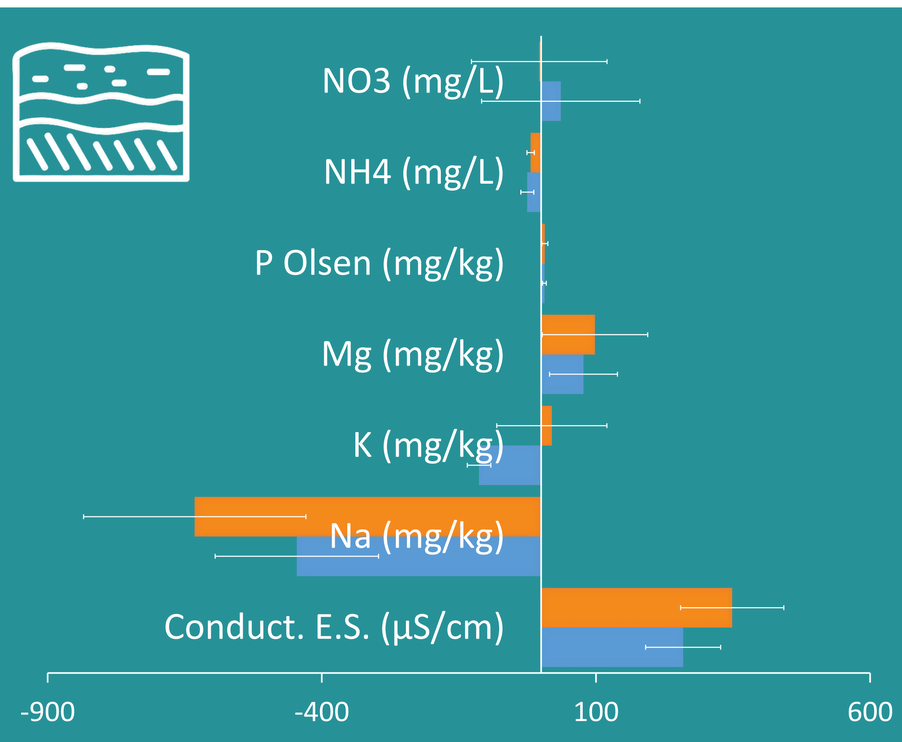
3. Results

FW: Irrigation water **RW: Reclaimed water**

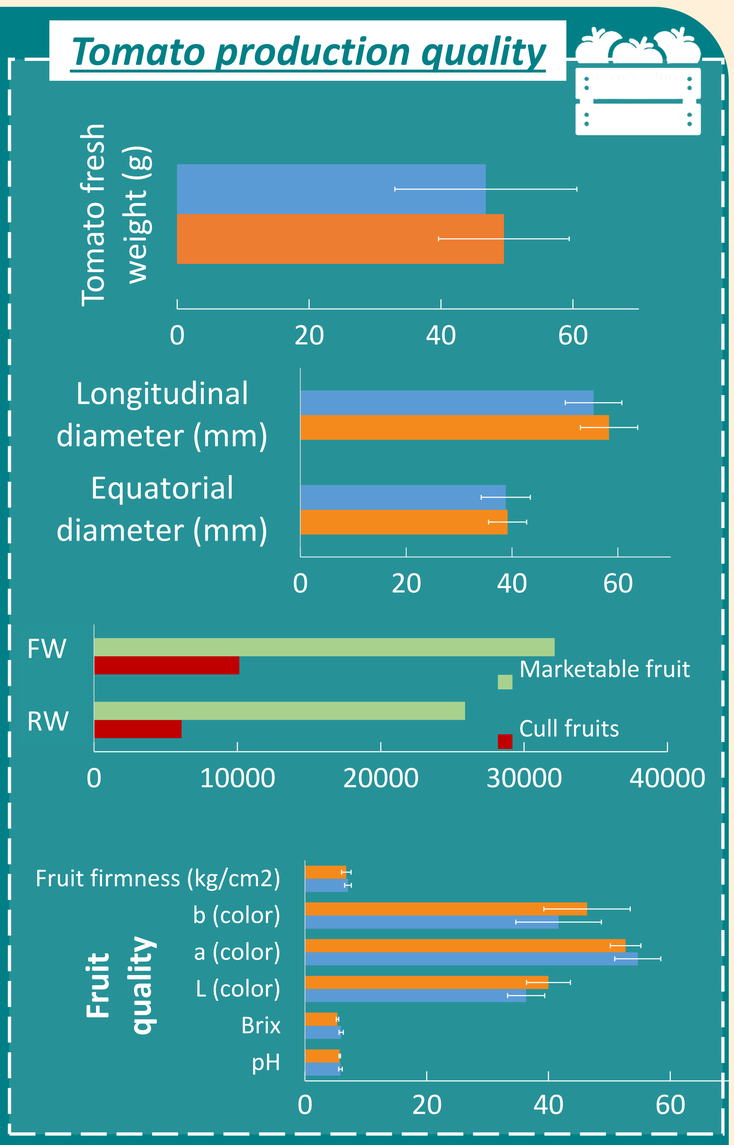
Analytical data of irrigation water

Parameter	FW	RW
pH	7,4	8,2
EC (µS/cm)	1442,5	1160,3
Total N (mg/l)	31,9	8,9
TKN (mg/l)	2,4	8,7
NH_4-N (mg/l)	0	4,6
NO_3-N (mg/l)	29,6	0,3
Total P (mg/l)	0	1,3
P-PO_4 (mg/l)	0	1
TSS (mg/l)	0,8	23,3
BOD_5 (mg/l)	3,7	16,3
E. Coli (CFU/100 ml)	12	68

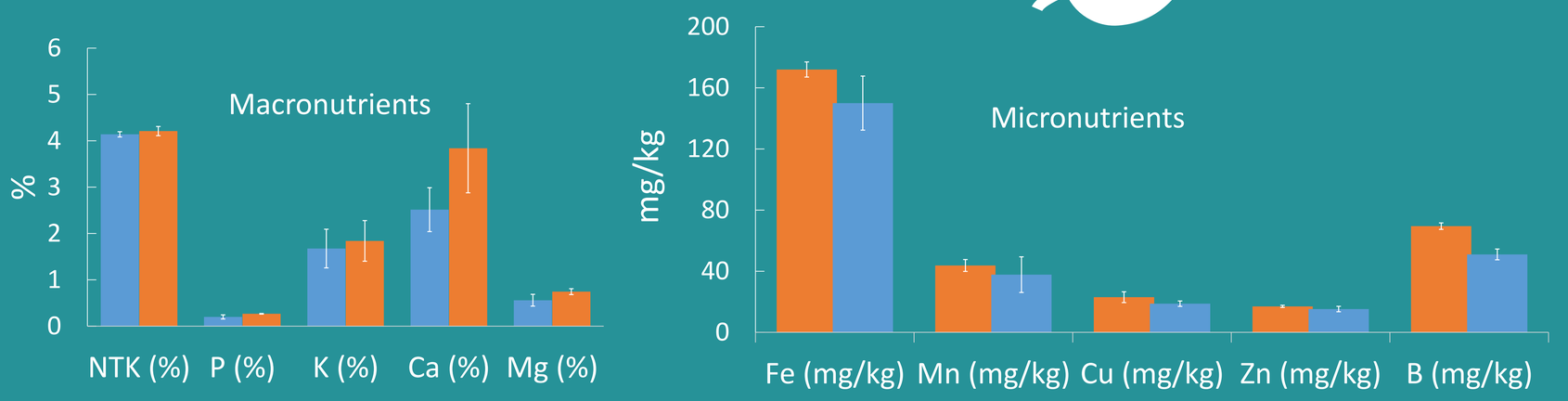
Averages changes in soil parameters (Post - Pre)



Tomato production quality



Foliar nutrient analysis



Soil samples from plots irrigated with reclaimed water showed a slight increase in electrical conductivity. Foliar analyses indicated higher concentrations of both macro- and micronutrients in plants receiving reclaimed water. Regarding fruit quality, no differences were observed between treatments in terms of colour, pH, °Brix, or firmness. Tomatoes irrigated with reclaimed water showed a greater longitudinal diameter, while no significant differences were detected in equatorial diameter or unit fruit mass.

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MADRID, SPAIN

TREATED URBAN WASTEWATER IRRIGATION IN OLIVE ORCHARDS: EFFECTS ON WATER RELATIONS AND CROP PERFORMANCE

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Introduction

Water scarcity is one of the main constraints to agricultural sustainability, particularly in Mediterranean, arid, and semi-arid regions. The reuse of treated urban wastewater (TUWW) for irrigation has emerged as a promising strategy to mitigate water shortages, enhance resource efficiency, and promote circular economy. Therefore, this study aimed to evaluate the agronomic and physiological responses of Olea europaea L. 'Cobrançosa' cultivar to irrigation with treated urban wastewater under full and deficit irrigation strategies. Specifically, the study assessed: (i) olive yield and fruit fat content; (ii) plant water status through stem water potential and relative water content; and (iii) structural and physiological traits related to stress response, including specific leaf weight, electrolyte leakage, and soluble wax content in leaves and fruits

Material and Methods

The experimental trial was conducted during the 2025 irrigation season in an olive orchard established in 2003 and located in Mirandela, northeastern Portugal. The region is characterized by a Mediterranean climate, with hot, dry summers, mild winters, and predominantly clay loam soils. Four drip irrigation treatments were implemented in the olive orchard:

- **T1**: Conventional water (CW) and full irrigation at 100% ET_c;
- **T2**: Treated urban wastewater (TUWW) and 100% ET_c;
- **T3:** TUWW and regulated deficit irrigation at 75% ET_c (RDI);
- **T4**: TUWW and continuous deficit irrigation at 75% ET_c (SDI)

Olives production and fat Content

Ten representative olive trees per treatment were sampled, and the production of each tree was individually collected and weighed in order to assess yield. Additionally, a representative olive sample was collected (five trees/treatment)and subsequently milled to obtain an olive paste. The fat content of the paste was then determined using the SpectraAlyzer OLIVE analyser from Zeutec.

Plant water status assessment

Plant water status was assessed by measuring water potential using a Scholander pressure chamber in the morning and at midday. Relative water content (RWC) was determined from three leaves per tree and replicate by measuring fresh weight (FW), turgid weight (TW; after 24 h rehydration), and dry weight (DW; after oven-drying at 60 °C for 48 h). RWC (%) was calculated as [(FW − DW)/(TW − DW)] × 100. Five trees per treatment were sampled for these measurements.



Figure 1. Steps involved in measuring xylem water potential using the Scholander chamber (A – Inserting the foil bag into the twig; B – Adjusting the clamp to the twig's diameter and inserting it into the chamber; C – Measurement)

Leaf and fruit structural and physiological traits

Specific leaf weight (SLW) was determined as the ratio between leaf dry mass and leaf area. Leaf electrolyte leakage (EL) was determined following conductivity measurements before (CE1) and after autoclaving (CE2) leaf discs (0.8 cm diameter) incubated in deionized water for 24 h at 25 °C, and EL (%) was calculated as (CE1/CE2) × 100.

Soluble cuticular wax content was determined according to the method described by Hamilton (1995). For each treatment, 2 leaves and 2 olive fruits per replicate (n = 5) were immersed separately in 50 mL of chloroform:methanol (75:25, v/v) for 2 min at 25 °C under continuous agitation. Extracts were air-dried until complete solvent evaporation, and the remaining residues were quantified gravimetrically. Soluble wax content was expressed as µg cm^{-2} for leaves and µg g^{-1} FW for fruits. For all these measurements five replicates per treatment were used

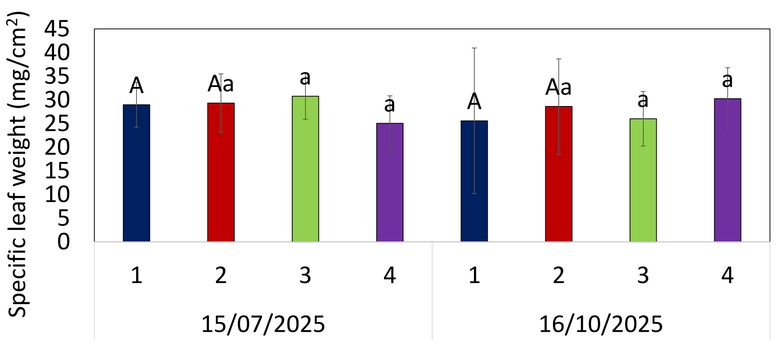


Figure 7. Specific leaf weight (SLW) (mg cm^{-2}) obtained from from four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

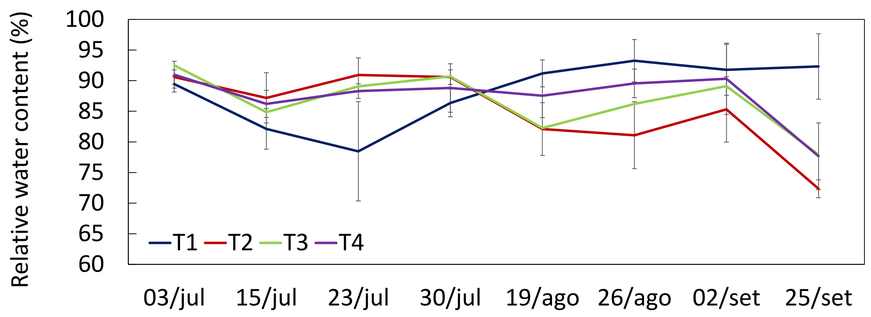


Figure 2. Variation in relative water content under four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

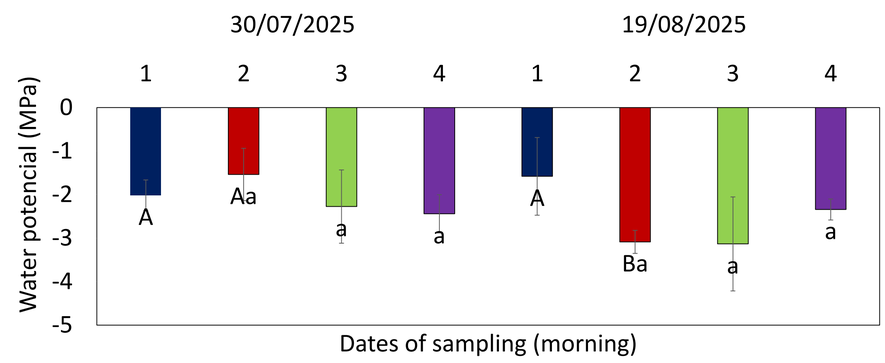


Figure 3. Variation of shoot water potential measured in the morning in four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

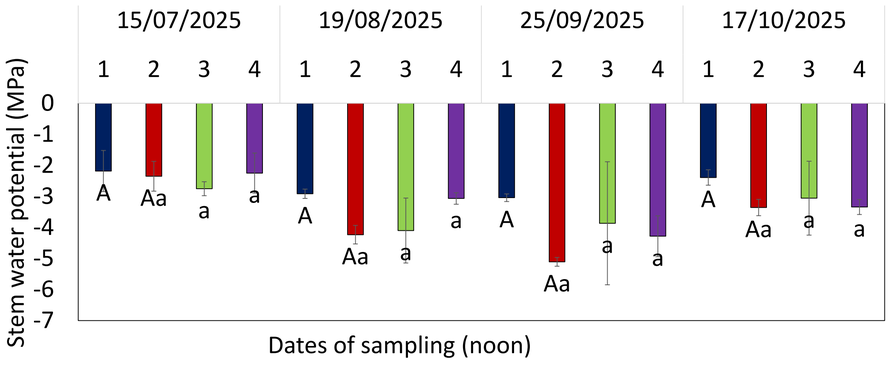


Figure 4. Variation in stem water potential at midday in four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

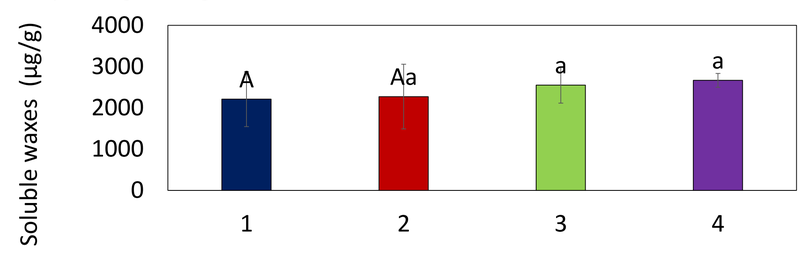


Figura 5. Soluble waxes content in olives (µg/g) obtained from four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

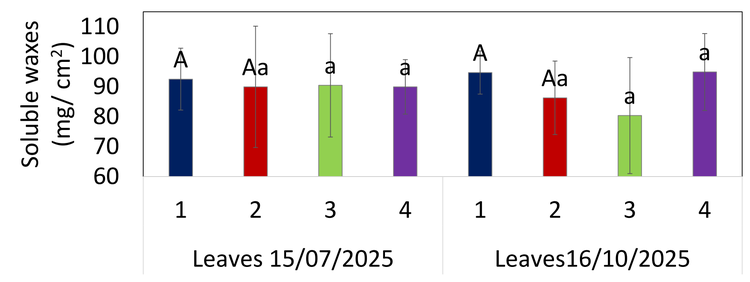


Figure 6. Soluble waxes content in leaves (mg/cm^2) obtained from four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

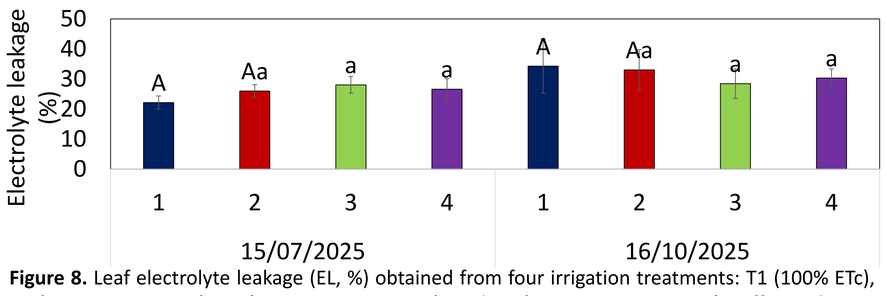


Figure 8. Leaf electrolyte leakage (EL, %) obtained from four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

Results and Discussion

Olive production and fat content

Treated urban wastewater (T2) performed similarly to conventional water (T1) under full irrigation (Table 1). Within wastewater treatments, RDI (T3) reduced fresh yield, whereas SDI (T4) maintained productivity. Dry yield was unaffected, while fat content tended to increase under deficit irrigation, particularly in T4. However, irrigation system constraints occurred during the oil accumulation period in the wastewater treatments, which may have influenced fruit fat content and should be considered when interpreting these results.

Table 1. Olive Production (kg/tree), in fresh and dry matter basis (n = 10), and fat content (FC, %, n = 5) of 2025 harvest from four irrigation treatments: T1 (100% ETc), T2 (TUWW 100% ETc), T3 (TUWW75% ETc, RDI), and T4 (TUWW 75% ETc, SDI). Different letters indicate significant differences ($p < 0.05$). Uppercase letters compare water sources; lowercase letters compare irrigation regimes.

Treat	Production (kg/tree, FW)	Production (kg/tree, DW)	FC (%)
T1	41.4 ± 8.8 A	18.6 ± 3.9 A	19.6 ± 1.0 A
T2	37.3 ± 7.9 Aa	16.6 ± 3.6 Aa	17.1 ± 2.3 Aa
T3	29.1 ± 5.1 b	13.3 ± 2.7 a	19.4 ± 1,6 ab
T4	35.2 ± 6.2 ab	16.3 ± 2.8 a	20.5 ± 1.5 b

Plant water status assessment

The RWC values (Fig. 2) were stable values among treatments, indicate that all irrigation regimes were able to maintain good leaf hydration.

Stem water potential in the morning (Fig.3) showed higher values under full irrigation, while deficit irrigation treatments indicated greater water stress.

Stem water potencial at noon (Fig.4) show that values are more negative in all treatments due to increased evaporative demand. This effect was more pronounced under deficit irrigation treatments, where fully irrigated treatments maintained comparatively higher water potential values.

Leaf and fruit structural and physiological traits

In leaf wax content (Fig. 6) no significant differences were observed among treatments, indicating that neither the irrigation water source nor the irrigation regime substan tially affected leaf cuticular responses.

In olives fruit wax content (Fig.5) no statistically significant differences were found suggesting that wax accumulation remained stable under the different irrigation treatments applied.

In Specific leaf weight (Fig. 7) no significant differences were observed among treatments, these results suggest that neither the irrigation regime nor the irrigation water source had a substantial effect on leaf structural characteristics.

In Leaf electrolyte leakage (EL) (Fig. 8) the greatest differences were observed between the irrigation regimes, indicating that the amount of water applied had a greater impact on cellular stress than the source of the water, although a slight difference was detected because of the source of water.

Conclusion

Treated urban wastewater proved to be a viable alternative to conventional irrigation water, showing comparable yield, fat content, and plant physiological performance under full irrigation. Plant water status was generally maintained across treatments, although deficit irrigation increased water stress, as indicated by more negative stem water potential and higher electrolyte leakage, particularly under periods of high evaporative demand. Irrigation regime had a greater impact than water source, while leaf and fruit structural traits, including soluble waxes content and specific leaf weight, were largely unaffected. Among deficit irrigation strategies, SDI (75% ETc) showed the most promising performance, maintaining yield while increasing fruit fat content. These findings highlight the resilience of olive trees to moderate water deficit and support the use of treated urban wastewater combined with deficit irrigation strategies to improve water use efficiency without compromising key physiological, productive, and quality parameters. However, irrigation system constraints during the oil accumulation period may have influenced fat accumulation in the wastewater treatments and should be considered when interpreting the results.

References

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USE OF TREATED MUNICIPAL WASTEWATER FOR ALMOND IRRIGATION: EFFECTS ON SOIL PROPERTIES, TREE MINERAL NUTRITION, AND PERFORMANCE IN A SEMI-ARID REGION

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[1] CIMO, LA Sustec, Instituto Politécnico de Bragança, Portugal
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Introduction

Irrigation water is a valuable yet scarce resource throughout the Mediterranean basin, where prolonged summer droughts limit crop productivity. In Trás-os-Montes, Portugal, less than 10% of the arable land is currently irrigated.

Treated municipal wastewater (TWW) is a potential alternative water source for crop irrigation, provided its use does not negatively affect soil properties or tree performance. The I-ReWater project aims to enhance sustainable water management in irrigated agriculture across the SUDOE region by integrating regenerated urban water into agricultural systems.

The experiment and the preliminary results

This study reports preliminary results on the effects of TWW irrigation compared with freshwater at two irrigation levels: a full irrigation treatment (FI) to supply 100% of irrigation requirements (IR) during the irrigation period and a regulated deficit irrigation (RDI_{35}) covering the full IR until the beginning of kernel-filling stage and 35% of IR from this stage to harvest, in an almond orchard in Alfândega da Fé, northern Portugal, managed under organic farming practices.

Both water type and irrigation rate had significant effects on specific soil properties and tree mineral nutrition. TWW application and higher irrigation rates tended to increase soil electrical conductivity (Table 1), particularly in late summer, likely due to elevated exchangeable sodium and mineral nitrogen (data not shown). However, the observed values remained low, and potential salinity issues are expected to be reversible during the rainy season through salt leaching. Beneficially, TWW consistently increased leaf nitrogen concentrations (Figure 1), reflecting its higher nutrient content. TWW significantly increased almond yield (Figure 2), resulting in a mean yield of 842 kg ha^{-1}, whereas irrigation with freshwater yielded only 415 kg ha^{-1}. Irrigation at 100% ETc increased yield from 532 to 724 kg ha^{-1} compared with the 35% ETc irrigation level; however, this difference was not statistically significant ($P = 0.0887$). The observed yield response was attributed to the higher concentrations of essential nutrients, particularly nitrogen in TWW.

Preliminary conclusions

These findings suggest that TWW can be safely used as an alternative irrigation source, supplying nutrients while enhancing productivity in semi-arid regions.

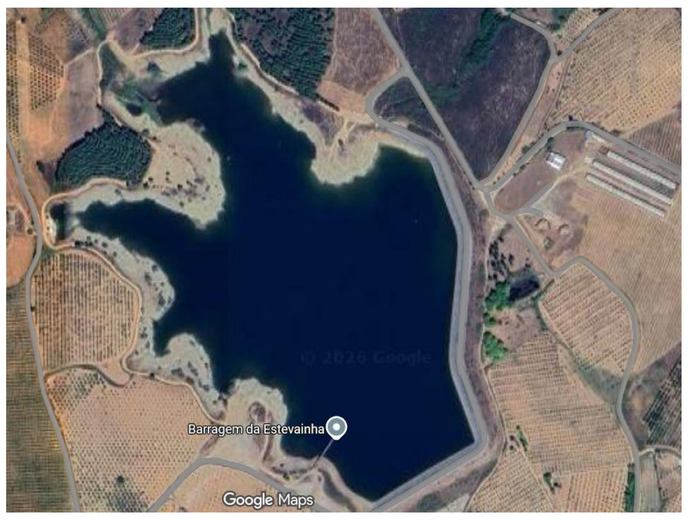








Table 1. Electrical conductivity in relation to water source, wetting bulb position, and depth.

	Conductivity ($cmol_+ kg^{-1}$)	
	23 May 2025	3 Sep 2025
Water source		
Reservoir water	65.41 a	69.57 b
Reclaimed water	66.58 a	105.03 a
Position within the wetting bulb		
Bulb center	61.09 b	79.81 b
Bulb edge	70.89 a	94.78 a
Sampling depth		
0-15 cm	69.90 a	101.78 a
15-30 cm	62.08 b	72.81 a

Within each factor (water source, position within the wetting bulb, and depth), means followed by the same letter do not differ significantly ($P < 0.05$).



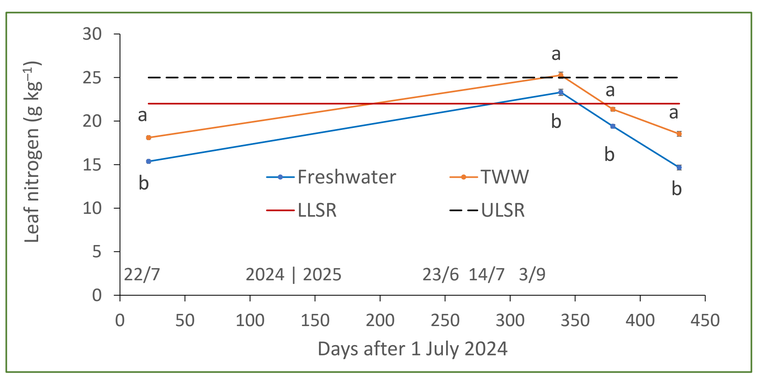


Figure 1. Leaf nitrogen concentration on four sampling dates as a function of water source (left) and irrigation rate (right), together with the lower (LLSR) and upper (ULSR) limits of the sufficiency range for almond trees.



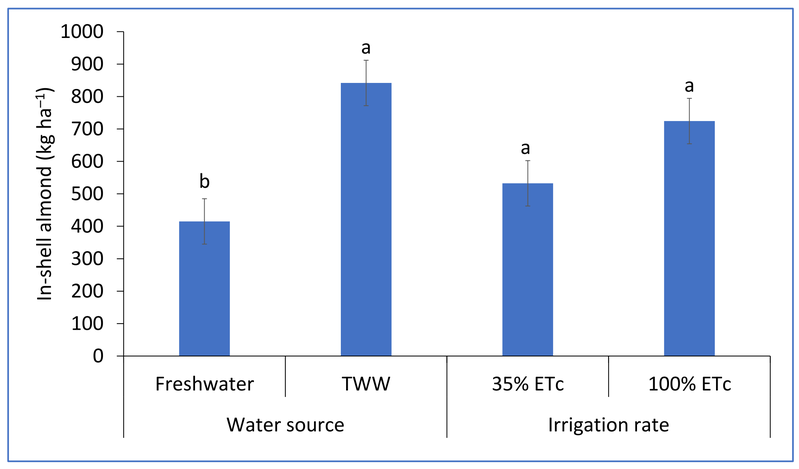


Figure 2. In-shell almond yield as a function of water source and irrigation rate.

Acknowledgements

To the project 'Sustainable management of water resources in irrigated agriculture in the SUDOE area (I-ReWater-S1/2.5/E0136)' co-funded by the programme INTERREG SUDOE.

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EFFECTS OF IRRIGATION WITH TREATED WASTEWATER IRRIGATION ON GRAPEVINE PHYSIOLOGICAL RESPONSES AND YIELD IN ALENTEJO REGION (PORTUGAL)

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[3] GI-1716 Projects and Planification. Agroforestry Engineering Department, Escuela Politécnica Superior de Ingeniería Lugo, University of Santiago de Compostela, Spain

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I-ReWater



Fig. 1: Experimental node with all the sensors connected, in one of the blocks.

Main Goal

Understanding the viability of using treated wastewater (TWW) as an alternative irrigation source in commercial vineyards.

Specific Tasks

Evaluate Plant Health: Assess the impact of TWW on grapevine water status and eco-physiological responses compared to conventional water.

Monitor Stress Levels: Utilize advanced precision agriculture tools as stem water potential, stomatal conductance, leaf temperature and drone-based multispectral imagery to track canopy temperature and water stress indices.

Assess Crop and Wine Quality: Determine if TWW irrigation affects technological ripening parameters (°Brix, pH, total acidity) and overall grape must and wine composition.

Material and Methods

- 2025 growing season
- 2 commercial vineyards in the Alentejo Wine Region:
  - Herdade do Esporão (*V. vinifera* cv. Viosinho; white variety)
  - Monte da Ravasqueira (*V. vinifera* cv. Trincadeira; red variety)
- 2 irrigation regimes
  - Conventional water
  - TWW
- Six experimental blocks per site (three per treatment)
- Meteorological data
- Stem water potential (Ψ_{stem})
- Stomatal conductance (g_s)
- Thermography: canopy–air temperature difference (ΔT) and Crop Water Stress Index (CWSI)
- Remote sensing (DJI Mavic 3 Multispectral): NDVI, GRVI and NDRE
- Quality and production parameters: °Brix, pH and total acidity, yield and pruning weight



Fig. 2: Experimental site at Herdade da Ravasqueira (cv. Trincadeira). Find the fox.



Fig. 3: Experimental site at Herdade do Esporão (cv. Viosinho).

Main Findings

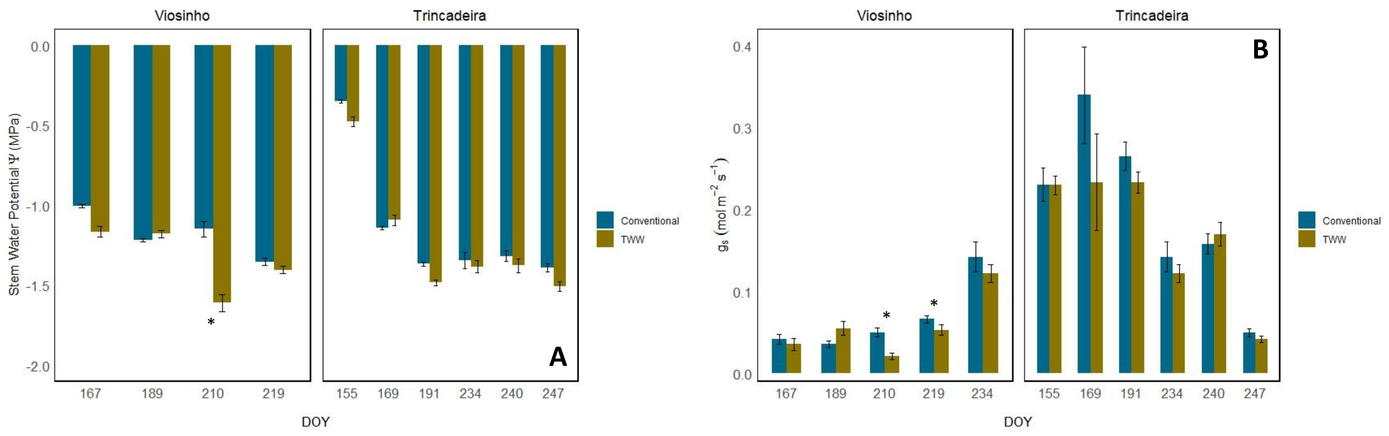


Fig. 4: A) Stem water potential, B) Leaf stomatal conductance, C) Canopy-air temperature difference and D) Crop Water Stress Index in Conventional and TWW treatments. Data represents averages ± SE. Asterisks represent significant diferences.

- TWW irrigation caused no detectable negative effects on vine water status or physiological activity
- Soil and leaf analyses showed no signs of chemical alteration
- Ψ_{stem} and g_s without significant differences
- Thermal and multispectral indices showed a gradual decline, consistent with natural canopy senescence and indicative of moderate water stress
- Yield and must composition differed between the two experimental sites, reflecting differences in cultivar, vineyard management and local conditions

Conclusion

- TWW represents a viable short-term alternative water source for vineyard irrigation, although long-term monitoring is required to confirm its sustainability under Mediterranean climatic conditions

Acknowledgements

The authors gratefully acknowledge Ravasqueira Vinhos S.A. and Esporão S.A that supported this work by providing access to their farms and by ensuring the necessary logistical support for the field activities. Their valuable collaboration made an important contribution to the work underlying this poster.

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HEDONIC SENSORY EVALUATION OF BEERS BREWED WITH HOPS IRRIGATED WITH RECLAIMED VS. CONVENTIONAL WATER

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Interreg Sudoe — Co-funded by the European Union

I-ReWater

Aim

*Although the Risk Management Plan for the Use of Reclaimed Water considers the effects on the environment and human and animal health, few studies have examined **end users' perceptions** of agricultural products irrigated with reclaimed water. For this reason, citizen participation in the processes of implementing the use of reclaimed water is crucial for its consolidation.*

To assess the response of citizens, as well as beer tasting experts, to the different experimental beers produced, through blind hedonic tastings.

Material & Methods





Within the **I-ReWater (SUDOE)** project, two pilot actions (**Galicia** and **Castilla-León**) have been implemented in which reclaimed water is used to irrigate hop (*Humulus lupulus*) during the 2024 and 2025 seasons. Four beers were brewed per growing season.

Field treatments:

hops irrigated with reclaimed water (RW) and, with conventional water (CW)

Citizens and Beer tasting experts:

2024 - 7 events – 161 participants

2025 - 6 events – 96 participants



Beers and hedonistic tasting



2024





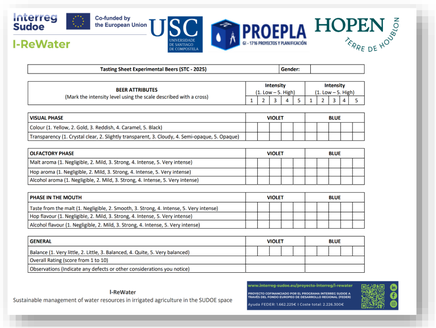
CW-Galicia

CW-Castilla-León

RW-Galicia

RW-Castilla-León







BUBELA
PASTAS E CERVEXAS ECOLÓXICAS

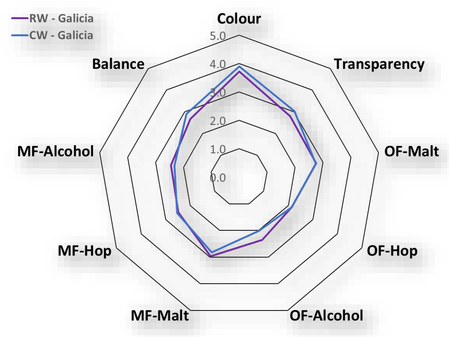


2025

Results

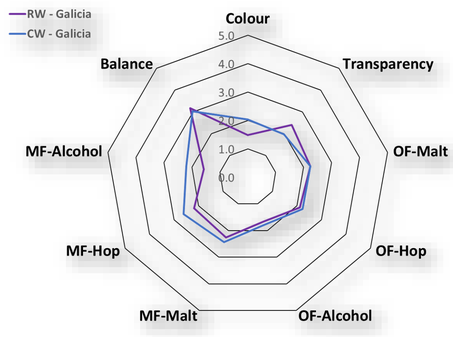
EXTRA SPECIAL BITTER (ESB)

	BLUE	PURPLE
Alcohol by Volume (% v/v)	**5.10**	**5.48**
Original Extract (ºP, % w/w)	14.19	14.17
Real Extract (% w/w)	6.60	6.00
Apparent Extract (% w/w)	4.79	4.05
Relative density (20/20˚C)	1018.79	1015.84
Alcohol (% w/w)	3.96	4.27
Bitterness Units (IBU)	**32**	**32**
pH	4.18	4.11
Color (EBC)	**70**	**66**

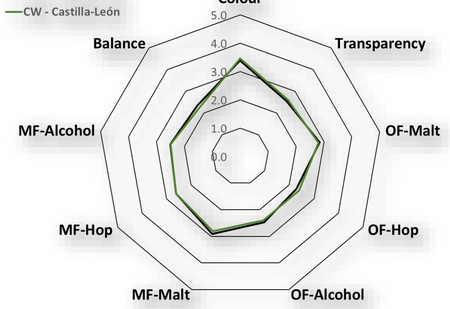


BLONDE ALE

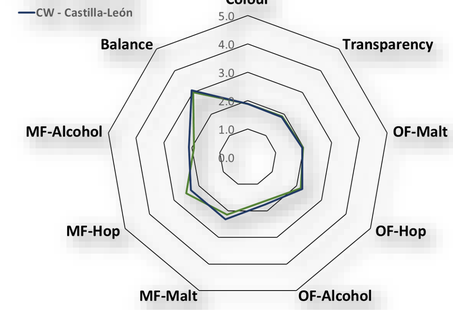
	BLUE	PURPLE
Alcohol by Volume (% v/v)	**4.77**	**3.53**
Original Extract (ºP, % w/w)	15.36	11.26
Real Extract (% w/w)	8.36	5.93
Apparent Extract (% w/w)	6.68	4.65
Relative density (20/20˚C)	1026.40	1018.24
Alcohol (% w/w)	3.68	2.74
Bitterness Units (IBU)	**25.0**	**13.2**
pH	4.13	4.11
Color (EBC)	**11.5**	**8.0**



	WHITE	GREEN
Alcohol by Volume (% v/v)	**6.06**	**6.25**
Original Extract (ºP, % w/w)	14.02	14.03
Real Extract (% w/w)	4.93	4.65
Apparent Extract (% w/w)	2.78	2.43
Relative density (20/20˚C)	1010.83	1009.45
Alcohol (% w/w)	4.74	4.90
Bitterness Units (IBU)	**20**	**18**
pH	4.22	4.22
Color (EBC)	**53**	**53**



	WHITE	GREEN
Alcohol by Volume (% v/v)	**3.47**	**3.46**
Original Extract (ºP, % w/w)	10.62	10.59
Real Extract (% w/w)	5.35	5.33
Apparent Extract (% w/w)	4.08	4.06
Relative density (20/20˚C)	1015.99	1015.90
Alcohol (% w/w)	2.70	2.69
Bitterness Units (IBU)	**16.4**	**17.2**
pH	3.95	3.95
Color (EBC)	**7.9**	**7.9**



Conclusions

- General public and experts did not detect differences between beers made with hop cones irrigated with water from different sources.
- Our results supports the future viability of including reclaimed water in the mix of water resources for irrigation, ensuring product quality and food safety.

Acknowledgments

This research has been developed within the framework of the I-ReWater project (S1/2.5/E0136), co-funded by the Interreg SUDOE Programme.

LU.TE.GA.. Lúpulos del Bierzo. SAT Lúpulos de León and GESTAGUA.

REUSE EUROMED 2026

EURO-MEDITERRANEAN CONFERENCE ON WATER REUSE



JUNE 17-19, 2026

SAN FERNANDO DE HENARES

MADRID, SPAIN

SOCIAL ACCEPTANCE AND GOVERNANCE CHALLENGES OF RECLAIMED WATER REUSE IN SPANISH AGRICULTURE: EVIDENCE FROM MEDITERRANEAN RIVER BASINS

Vidal-Ruiz, Alba[1], Alba-González, Anabel[1], Gesto-Casás, Tania[1], Ribas-Álvarez, Alfonso[1]
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INTRODUCTION AND AIM

Water scarcity: structural challenge in Spain (particularly in Mediterranean regions).
Strategic alternative: **reclaimed water** following: EU 2020/741 and RD 1085/2024.
Aim: to **analyse** reclaimed water reuse in Spanish agriculture **from a social science perspective**, focusing on: social acceptance, governance and institutional trust, and economic feasibility.

METHODOLOGY

2000 → Systematic literature review; Quality & mixed methods; Policy & institutional analysis → 2026

KEY RESULTS

SOCIAL ACCEPTANCE

- Strongly influenced by risk perception (HSE)
- Presence of "yuck factor"
- Improves with information and stakeholders participation

GOBERNANCE & TRUST

- Participation → increases acceptance
- Transparency in water quality → builds trust
- Institutional coordination is critical
- Irrigation communities play a key role

ECONOMIC CONTRAINTS

- High cost of energy, infrastructure and operation
- Low competitiveness *vs* conventional water
- Difficulty applying cost recovery principles
- Financial uncertainly reduces adoption

STUDY CASE – River basins of Spain

Progressive integration into irrigation systems
Importance of user perception and trust



Successful implementation through:
- Participatory approaches
- Collective management

Persistent challenges:
- Costs
- Salinity issues
- Environmental impacts

Fig 1. Map of Spain showing the river basins of Guadiana, Júcar and Segura

CONCEPTUAL MODEL

Reclaimed water adoption depends on three socio-technical dimensions:

SOCIAL ACCEPTANCE

Perceptions, information, engagament

GOVERNANCE (TRUST & PARTICIPATION)

Transparency, participation, institutional coordination

ECONOMIC VIABILITY

Costs, competitiveness, financial sustainability

KEY CHALLENGE

Gap between policy and local reality

Despite strong regulation:

- Economic barriers persist
- Social acceptance is not guaranteed
- Technical feasibility ≠ real adoption

CONCLUSIONS

- Water reuse is a socio-technical process, not just a technical one.
- Social acceptance is a core condition, not a secondary factor.
- Effective governance requires participation, transparency & trust.
- Economic feasibility is a critical barrier, especially for irrigation communities.

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