# Unlocking the potential of treated wastewater reuse: The case study of Lisbon


***I. Meireles*, V. Sousa**, A.P. Falcão**, A.B. Gonçalves*****

**** RISCO, Department of Civil Engineering, University of Aveiro, Aveiro, 3810-193, Portugal (E-mail: imeireles@ua.pt)***

***** CERIS, Department of Civil Engineering, Architecture and Georesources, IST-University of Lisbon, Lisbon, 1049-001, Portugal***


## Introduction

Water scarcity is already a reality in many parts of the globe, and climate changes are expected to exacerbate and expand it further. One of the regions of the globe in this situation is the Mediterranean, where some countries (e.g. Portugal, Spain, Italy, Greece) already record a decreasing trend in the annual rainfall of more than 20 mm/ 10 years (Caloiero et al., 2018). For Portugal, specifically, the rainfall is expected to decrease further, but with a significant seasonal influence. The rainfall decrease is forecasted to be larger during the dry periods (above 50% decrease in the summer) and less in the wet periods (marginal decrease in the winter) (Soares et al., 2015). In this context, the urge to adopt a more sustainable water consumption becomes crucial.

One of the options to promote a more sustainable urban water consumption is the use of treated wastewater in non-potable water uses. In Europe, this is a particularly interesting option for medium to large urban areas, since the Urban Waste Water Treatment Directive (Council Directive 91/271/EEC) requires urban areas with over 10 000 people discharging in sensitive areas to implement at least tertiary treatment. Furthermore, the recent revision of the directive proposes making this requirement mandatory for all wastewater treatment plants treating a load equal to or greater than 100 000 p.e., along with the need to implement also quaternary treatment to eliminate micro pollutants.

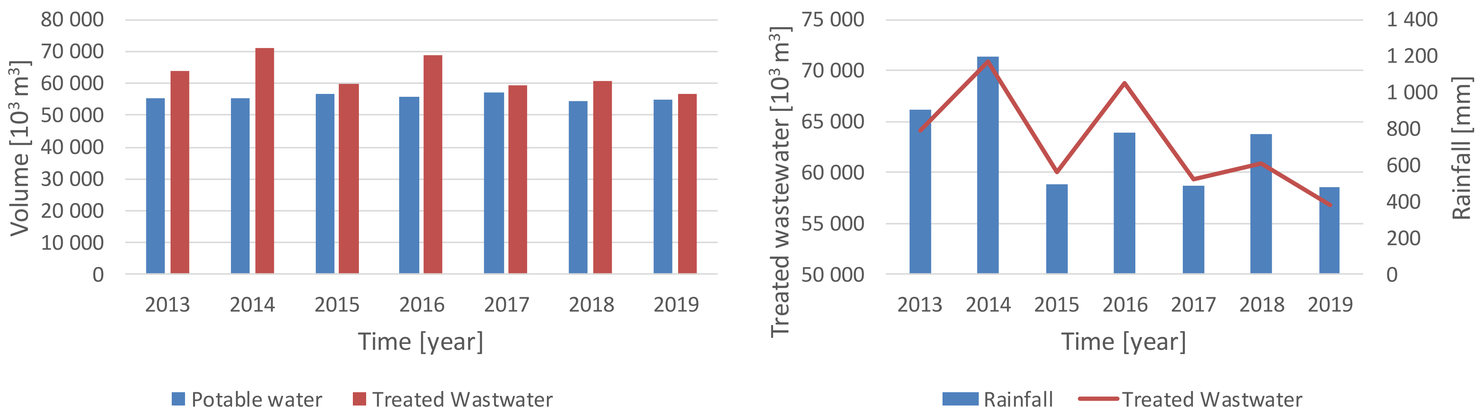


Figure 1 - Relation between treated wastewater and (left) potable water consumption and (right) rainfall in Lisbon

This context will create a steady and controlled flux of high-quality treated wastewater that will be available, in most cases, close to urban consumers. In Lisbon, the amount of wastewater treated annually even exceeds the water consumption volume due to the existence of combined sewer networks in the oldest parts of the city, along with infiltration and wrong connections (Figure 1).

In theory, it would be possible to create a close loop of the urban water cycle. In practice, this is not possible because most of the consumptive use (e.g., irrigation and consequent evapotranspiration) occurs when there is no rainfall.

## Results & Discussion

The key limitation for using treated wastewater, in addition to the question of public acceptance, is the disruption that the construction of a non-potable water network entails in a consolidated urban space.


Figure 2 - Location of the Monsanto-Santa Apolónia flood relief tunnel (yellow in the left image) and Alcântara WWTP

In Lisbon, the ongoing construction of two large flood relief tunnels crossing the city created a unique opportunity of installing a non-potable water main inside one of them (Figure 2), enabling the supply of the treated wastewater from the Alcântara wastewater treatment plant (WWTP) to various points throughout the city. In the future, these infrastructures could be complemented with short surface non-potable water distribution networks to reach critical points (e.g., Parque Eduardo VII garden).

The Alcântara WWTP serves a population of 750 000 inhabitants, more than the population of Lisbon. The treated wastewater exceeds $44x10^6$ $m^3$ per year, close to the $55x10^6$ $m^3$ of potable water consumed per year in Lisbon. The treated wastewater per month always exceeds $3x10^6$ $m^3$, implying that there is more than enough treated wastewater available to replace the $6x10^6$ $m^3$ of potable water that are still used for irrigation and street cleaning every year in Lisbon (Figure 3).

The majority of the non-potable water uses outside by the municipality is for irrigation (only $0.5x10^6$ $m^3$ is for street cleaning) and is concentrated between June and October only.

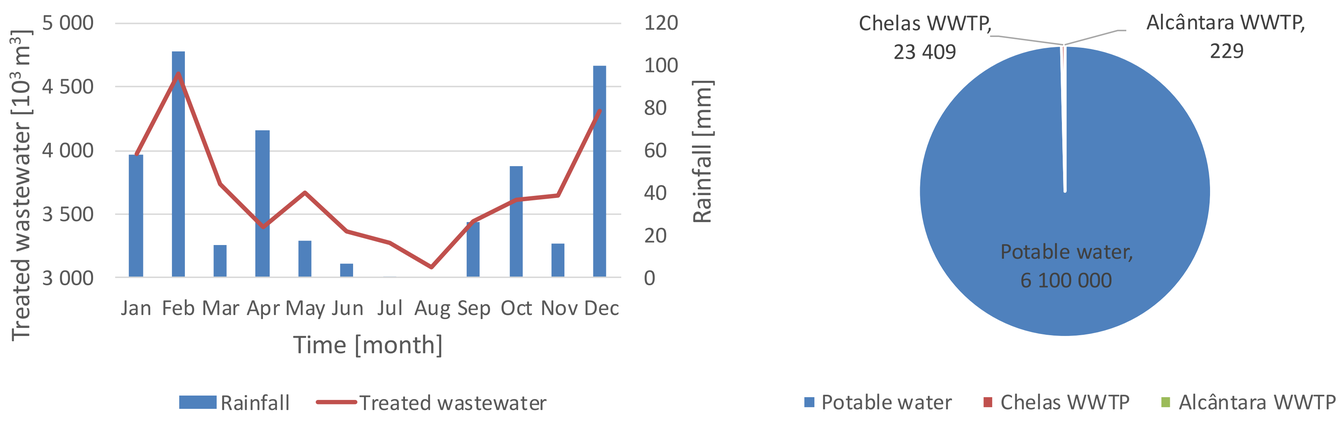


Figure 3 – Monthly treated wastewater at Alcântara WWTP (left) and origin of the water used for irrigation and street cleaning in Lisbon (left)

## Conclusions

There is an entire chain of benefits associated with replacing the potable water presently used for irrigation and street cleaning in Lisbon by treated wastewater. The specific energy consumption of the potable water supply in Lisbon averaged 1 kWh/$m^3$ over the last years (ranging from 0.95 to 1.05). Consequently, replacing the potable water used for irrigation and street cleaning alone would represent gross annual savings of $6.1x10^6$ kWh. Despite the decreasing trend of the specific emissions from electricity consumption (from over 500 gCO2eq/kWh, in 2000, to 234 gCO2eq/kWh, in 2022), these energy savings would still avoid the emission of 1 427 tonnes of green house gases.

Converting these gross savings into monetary terms, it is estimated that: i) the potable water is worth 11.285 million euros (1.85 €/$m^3$ – water supplier); ii) the energy represents 0.61 million euros (0.10 €/kWh – energy supplier); and iii) the green house gases are 114 thousand euros (80€/tonne CO2eq - EU Emissions Trading System).

### References


Caloiero, T., Caloiero, P. and Frustaci, F. (2018). Long-term precipitation trend analysis in Europe and in the Mediterranean basin. Water and Environment Journal, 32, 433-445. https://doi.org/10.1111/wej.12346

Soares, P.M.M., Cardoso, R.M., Ferreira, J.J. and Miranda, P.M.A. (2015). Climate change and the Portuguese precipitation: ENSEMBLES regional climate models results. Climate Dynamics, 45, 1771–1787. https://doi.org/10.1007/s00382-014-2432-x



The authors would like to express appreciation for the data made available by the Municipality of Lisbon, Águas do Tejo Atlântico, The Portuguese Institute for Sea and Atmosphere and The Water and Waste Services Regulation Authority