Gardens & Landscapes

Introduction: Scope, Goals and Outcomes of AQUA's Project

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Water scarcity is one of the biggest problems in the Anthropocene. Given the problems that the world is facing today related to climate change and, consequently, lack of water and the increase in the desertification process, we hypothesized that water management in Villas and monastic enclosures of the early modern period were efficient, resilient and sustainable. In Portugal, between Francisco de Holanda's utopian project for an aqueduct (1571) and the construction of the Águas Livres Aqueduct, inaugurated in 1748, which brought water from Sintra to Lisbon over 58 km, knowledge about water management was developed. The arrival of water and the consequent construction of more than twenty fountains, increased the amount of drinking water available to the population. However, the modern system of plumbing and sanitation in the city dates back to the second half of the nineteenth century. However, wise water management practices were already being employed in the context of farms and fences, turning their gardens into laboratories for hydraulic innovations, which proved essential for future developments in hydraulic systems. This water management was governed by sustainability principles associated with an efficient use of water.

Therefore, in 2017, we designed a project – HORTO AQUAM SALUTAREM: Water Wise Management in Early Modern Gardens in Portugal (AQUA, PTDC/HAR-HIS/28627/2017) – to contribute to this challenge by adding historical knowledge of the management of traditional hydraulic systems and sustainable irrigation practices (https://aqua.ciuhct.org). It was funded by the Portuguese Foundation for Science and Technology between October 2018 and September 2022, with 219.623,60€.

History leads this multidisciplinary project involving the collaboration of historians, engineers and landscape architects to promote the crossing of knowledge between the Humanities and Sciences. In order to give an overview of the team, the case-studies and the interdisciplinary methodologies, I add the poster made for CienciasDay, held at the Faculty of Sciences of the University of Lisbon in November 2021.

The aim of the AQUA project is to assess the effectiveness of water management from the sixteenth to the nineteenth centuries and to establish corresponding recommendations on the sustainability of energy and water systems in contemporary gardens and landscapes, which unfolds into three specific objectives: 1) To contribute to the history of water; 2) To evaluate the effectiveness of early modern water management in general terms; 3) To establish specifications for water saving in gardens and landscapes, enabling the development of new models of sustainable water use.

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HORTO AQUAM SALUTAREM

Water Wise Management in Gardens in the Early Modern Period

(PTDC/HAR-HIS/28627/2017)

CIUHCT

FCT Fundação para a Ciência e a Tecnologia

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The AQUA project aims to evaluate water management efficiency from the 16th to the 19th centuries and correspondingly to establish recommendations on water and energy saving methods in contemporary gardens and landscapes, enabling future eco-innovations. In Portugal, the existence of a large body of knowledge and a cohort of hydraulic experts is evident between the utopian project for an aqueduct by Francisco de Holanda (1571) and the construction of the Free Waters Aqueduct, inaugurated in 1748, bringing water to Lisbon from Sintra over a distance of 58 km. Despite water distribution and drainage systems having been only built in the second half of the 19th century, before that, advanced water management practices were developed and applied in the context of villas and monastic enclosures. These gardens *qua* laboratories for hydraulic innovations were essential to further developments in water supply systems. They were governed by sustainability principles associated to water savings and water wise management. History of Science and Technology leads this multidisciplinary project involving collaboration between historians, engineers and landscape architects to promote bridging boundaries between the Humanities and the Sciences.

https://aqua.ciuhct.org

Aqua - Horto Aquam Salutarem

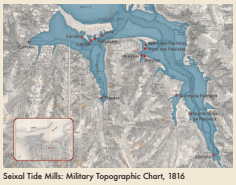
SEIXAL — A 'pocket of innovation'. The intelligent use of water to produce energy: tide mills and local expertise

SHORT DOCUMENTARY: *O USO INTELIGENTE DA ÁGUA NO SEIXAL 24´*

See the full documentary on the Aqua website or at: https://www.youtube.com/watch?app=desktop&v=lFsuZlsgJrM&feature=emb_logo

GIS - STORY MAP: *O USO INTELIGENTE DA ÁGUA NO SEIXAL´*, highlight to the tide mills:

See more on the Aqua website or at: https://storymaps.arcgis.com/stories/984060fcd3ec4eadb8d998187450 26e0

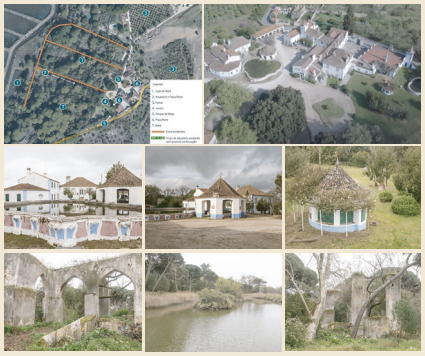


Seixal Tide Mills: Military Topographic Chart, 1816

googlemaps, 2021

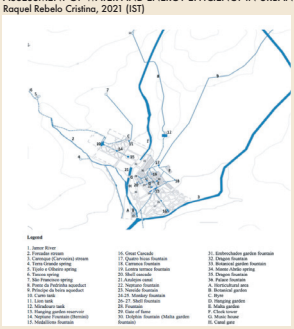
THE VILLA OF THE PRINCESS - SEIXAL

Along with other villas, is located in the municipality of Seixal, on the left bank of the Tagus river, being considered a perfect interpretation of history, science, technology and nature, where the water element plays a leading role. The fact that it is, among the others, the paradigmatic example of how a villa in that region made use of its water resources in the Modern Age, led to it being considered as a case study for the AQUA project.

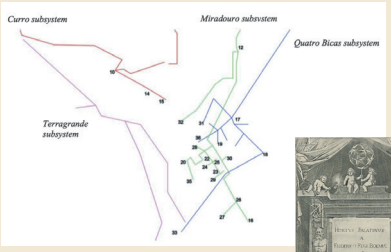


QUELUZ — AQUA's Master thesis demonstrated that historical gardens' consumption of water is lower than in contemporary gardens

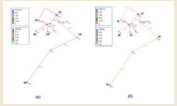
ASSESSMENT OF WATER AND ENERGY EFFICIENCY IN URBAN AND HISTORICAL GARDENS
Raquel Rebelo Cristina, 2021 (IST)



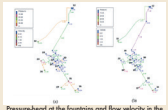
Scheme of the water supply system of the National Palace of Queluz and it gardens (adapted from Correia 2015).



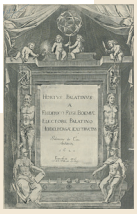
Schematic representation of the water supply and irrigation system of the National Palace of Queluz

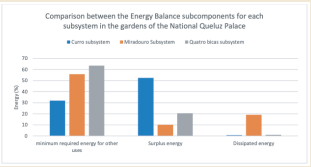


Pressure-head at the fountains and flow velocity in the pipes of the Quatro Bicas subsystem for (a) scenario 1 and (b) scenario 3



Pressure-head at the fountains and flow velocity in the pipes of the Miradouro subsystem for (a) scenario 1 and (b) scenario 3

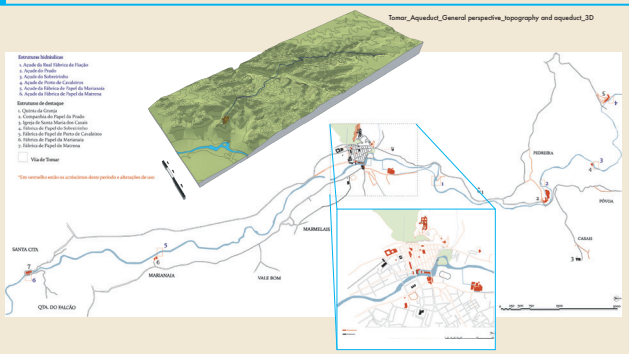


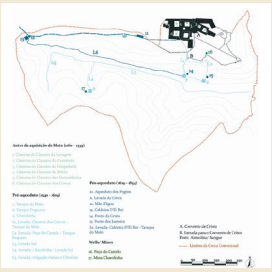


Energy Balance subcomponents for each subsystem in the gardens of the National Palace of Queluz

TOMAR — The Order of Christ had absolute control over the territory, the river and the hydraulic devices from medieval times until 1834

Tomar_Aqueduct_General perspective_topography and aqueduct_3D





To achieve these goals, AQUA is organized into four interrelated conceptual and methodological axes: 1) The study of accessible theory in Portugal through treatises on water and hydraulic management; 2) The study of manuscripts on water and its devices in gardens to analyse how theoretical knowledge was applied; 3) Fieldwork on the four selected case studies for their virtual 3D reconstruction; 4) Pilot experiments carried out in the water laboratory to assess the energy efficiency and sustainability of water in early modern villas and monastic enclosures.

This interdisciplinary work between historians of science and technology and historians of art, hydraulic engineers and landscape architects allowed us: 1) To demonstrate how local expertise in the Tagus' estuary was able to take advantage of water for the production of energy through tide mills (https://www.youtube.com/watch?app=desktop&v=IFsuZlsgJrM); 2) To evaluate the energy produced by water wheels as historical research on the Mouchão hydraulic wheel, in Tomar, also fuelled the pilot experiments that are being carried out at the IST Water Laboratory to reconstitute the wheel on a small scale if measuring the amount of energy per this produced; 3) To measure the consumption of water in historical gardens such as Queluz in comparison with contemporary gardens; 4) To deepen the knowledge of technical aspects described in hydraulic treatises circulating in Portugal (https://aqua.ciuhct.org/hydraulic-treatises). Finally, but perhaps most importantly, AQUA was constituted as a training space for a new generation of researchers in these topics, which had been neglected until recently, having already given rise to three completed master's theses, two others on going, and an internship for a young Italian researcher who won a scholarship from the University of Cagliari.

Following the book *The History of Water Management in the Iberian Peninsula between the 16th and 19th centuries* (Springer, 2020), this special issue of *Garden & Landscapes* journal stands as an important output of AQUA's team to reveal some of its results regarding Iberian water devices, water management and hydraulic systems' efficiency.

Patricia Monteiro's study reveals the role of local expertise in the intelligent use of water in Seixal, which took advantage of the region's geography and biophysical conditions to establish a series of tide mills dedicated to milling flour, whose demand increased exponentially at the end of fifteenth century with the need to produce biscuits for the Maritime Expansion. Tide mills' potential was inspirational for a group of national and foreign engineers, who developed projects to take advantage of this landscape, but by using modern engines. Unfortunately, due to political and economic reasons their projects were never implemented.

Magdalena Merlos and Victoria Soto-Caba's article on the gigantic waterwheel, the Azuda, in Aranjuez, in which the authors explore the technological background, namely the Islamic tradition of *norias* in Spain. Moreover, the authors address the context of Aranjuez as one of the most important settings of Philip II to foster innovation, even if based on millenary traditions and the same basic technological principles.

The third contribution by Clara Marques focuses on the power and control of the Order of Christ over the Nabão River. The investigation carried out on the hydraulic system of the Convent of Christ jumped the monastic walls and extended along the Nabão river, revealing the power of the Order of Christ over the entire territory, including the river. This article reveals the unpublished document of Bernardo Daniel de Moraes, in which he requires the establishment of an industry on the Nabão banks, including water devices to produce energy. The article also explores the answer given by the friars of the Convent of Christ championing their monopoly over the territory's water management.

The fourth contribution enrols hydraulic engineers and historians, and aims at evaluating the consumption of water of the Royal Palace of Queluz. Based on historical investigation of secondary bibliography and primary

sources, including documentation, iconography and ancient maps, as well as visits and photographs of recent restorations carried out at Queluz, it was possible to gather the majority of the data. This field work provided data on measurements of tubes, power sources and volume of water reservoirs needed for the calculations carried out by the hydraulic engineers who evaluated the water consumption in the garden. By comparing the water and energy balance of the National Palace in Queluz and the Carmona park in Cascais and a garden of Vale de Lobos in the Algarve, hydraulic engineering demonstrated that the use of water in the past was much more parsimonious and therefore, historic gardens are more resilient to water shortages. The system worked by gravity, so the energy cost is lower than in contemporary gardens. In the Queluz garden there are above all trees and shrubs adapted to the Mediterranean climate that do not require any water supply, while in contemporary gardens lawns dominate, requiring water resources that will be exhausted in the coming decades. On the other hand, historic gardens benefited from the wisdom and care of gardeners who only watered the beds and flowers when there was an absolute need, as opposed to automatic irrigation that waters even without being necessary, with two resulting losses - increasing water consumption and 'addict' plants that become thus more dependent on regular watering.

The scarcity of water in the Mediterranean, with a long dry summer, imposed not only the greatest possible storage, but also water wise management, taking advantage of and reusing all the water. AQUA's investigation in general revealed that the slogan often used today to draw attention to water shortages – 'each drop counts' – was a reality in Iberia until about a century ago.