HORTO AQUAM SALUTAREM – Water Wise in Gardens in the Early Modern Period

Summary

The HORTO AQUAM SALUTAREM project (hereafter referred as AQUA) 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. Water scarcity constitutes a major concern in the Anthropocene era. "Water innovation: Boosting its value for Europe" is a specific challenge of Horizon 2020.

AQUA is organized along four intersecting conceptual and methodological axes: 1) Study of theoretical knowledge circulating in Portugal through treatises on hydraulics and water management; 2) Usage of manuscripts concerning water management and works in gardens to shed light on how this expertise was applied in the field; 3) Field data collection on the four selected case-studies to enable their 3D computational reconstruction; 4) Pilot experiments carried out in the laboratory to evaluate the energy efficiency and water sustainability in the enclosed estates of the early modern period. Finally, the expertise built up will be used to create a computational program for garden irrigation that embodies knowledge from the past and new technologies. History leads this multidisciplinary project involving collaboration between historians, engineers and landscape architects to promote bridging boundaries between the Humanities and the Sciences.

AQUA international team sets three main goals: 1) To build historical knowledge on water management in the early modern period; 2) To evaluate early modern water management efficiency at a worldwide level; and 3) To establish specifications on water saving in gardens and landscapes, enabling the development of novel models of water saving.

CERIS developed two main activities described in the following sections.

Assessment of water and energy efficiency in urban and historical gardens

This activity aims to develop and apply a methodology to evaluate the water and energy consumption in urban and historical gardens. The methodology is based on water and energy balances and the associated performance indicators. The proposed balances include new components, such as the landscape water requirements, which is the theoretical plants water needs. These balances are applied to three case studies of different nature and characteristics: the gardens of the National Palace of Queluz (a historical garden) (Figures 1 and 2), Vale do Lobo urban gardens (a modern garden with a smart irrigation systems) and Marechal Carmona urban park (a garden with traditional irrigation system and recreational uses). The water balances allow to estimate and to compare yearly water consumption and to assess the importance of other water uses. The application of the water balance to consecutive years allows assessing the effectiveness of implemented measures for water demand reduction.

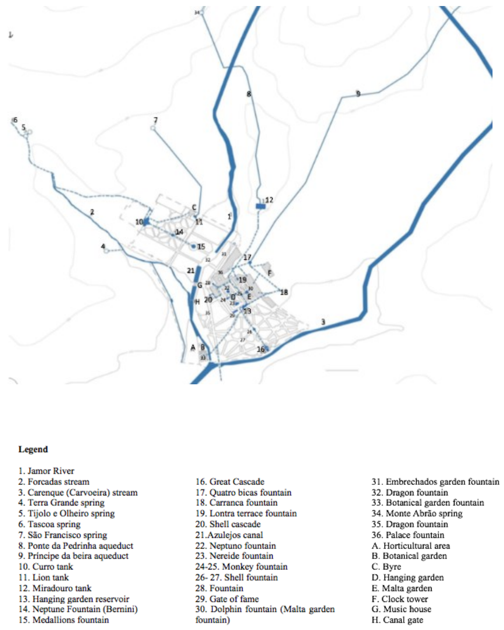


Figure 1. Scheme of the water supply system of the National Palace of Queluz gardens.

(a) (b)

Figure 2. Selected fountains and cascades from the gardens of the National Palace of Queluz (a) Medallions fountain, (b) Great cascade.

Results show that the studied historical gardens consume less water than the modern ones and that the implementation of smart irrigation systems effectively reduce water consumption in modern urban gardens. The application of the energy balance allows assessing the impact of water efficiency measures on energy efficiency

CERIS Civil Engineering Research and Innovation for Sustainability

Project Reference

PTDC/HAR-HIS-28627/2017 / LISBOA-01-0145-FEDER-028627

Leading Institution

FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências (Portugal)

Partners

IST-ID – Associação do Instituto Superior Técnico para a Investigação e o Desenvolvimento (Portugal)

CERIS Principal Investigator

Dídia Covas (didia.covas@tecnico.ulisboa.pt)

CERIS Research Team

Laura Monteiro, Nuno Martins, João Ferreira, Miguel Capelo, Raquel Cristina, Guilherme Macara

Funding

FCT – Fundação para a Ciência e a Tecnologia

Period

2018-2022

Total

237 154.80€

CERIS

36 100.00€

Project Website

aqua.ciuhct.org

and demonstrates that the historical gardens are more energy efficient than the modern ones. The proposed methodology can be applied to gardens with different water uses for the evaluation of the water and energy consumption and for the assessment of the effect of water and energy improvement measures.

Assessment of the hydraulic power of ancient water wheel

This activity aims at the investigation of the mechanical (hydraulic) power of undershot water wheels operating at variable rotational speeds. An extensive literature review on the multiple existing technologies for energy harvesting, including the classic solutions used in large hydropower plants and also solutions specific for small heads and powers (e.g. pumps operating as turbines, Archimedes screw turbines and water wheels).

An experimental facility composed of a small-scale water wheel installed in a horizontal flume, with a water recirculating pipe circuit, has been assembled specifically for carrying out this research (Figure 3). The facility is fully equipped for measuring hydraulic and mechanical parameters, namely an ultrasonic flowmeter, two pressure transducers, one torque sensor and one rotational speed sensor.

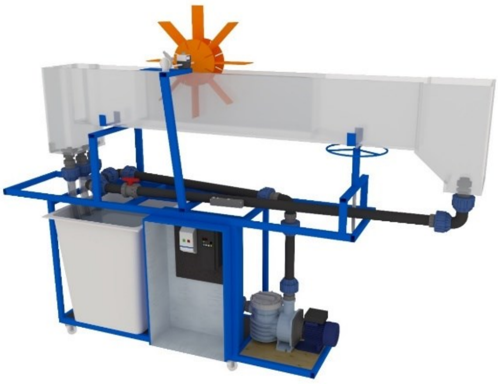


Figure 3. The experimental facility.

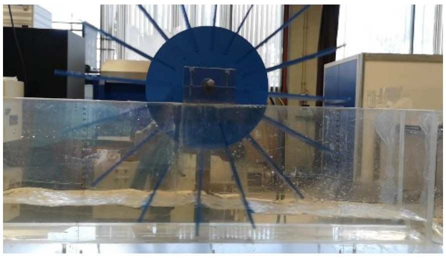
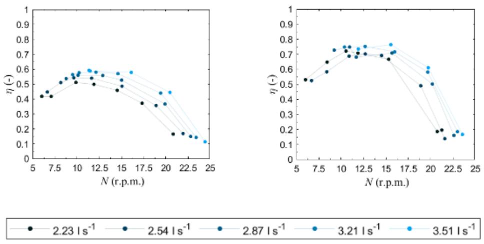


Figure 4. 16-blade water wheel.

Measurements are acquired using a data acquisition hardware from National Instruments™ connected to a computer. Two undershot water wheels with 8 and 16 plane blades are tested (Figure 4). Two theoretical models have been developed to estimate the hydraulic power: an energy-balance model and a mechanical model based on the equilibrium of static and dynamic forces applied to the water wheel. The characteristic curves of torque-flow rate, shaft power-flow rate and efficiency-flow rate (Figure 5) are determined and compared with the results obtained by the theoretical mechanical model. Main uncertainties of this model are discussed.



(a) (b)

Figure 5. Hydraulic efficiency curves for the (a)8-blade wheel and (b)the16-blade wheel.