Improving Water Efficiency in a Swimming-Pool Complex

Subjects: Water Resources

Contributor: Ana Maria Antão-Geraldes

Concomitantly, the possibility of recycling and reusing the water from filter backwashing was evaluated. The pools consumed 25.6% of water, the filter backwashing 24.5%, and the showers 34.7%. Despite the current impossibility of reducing water consumption in pools and filter backwashing, it is feasible to promote more efficient use of water through reducing water consumption by adopting simple water-saving initiatives for showers, taps, and flushing cisterns. These were organized into three distinct scenarios: (a) flushing cistern volume adjustment and the replacement of washbasin and kitchen taps; (b) flushing cistern volume adjustment and shower replacement and (c) flushing cistern volume adjustment, shower, washbasin, and kitchen taps replacement. Under scenarios 1, 2, and 3, the water consumption reduction was 8.0, 13.2, and 20.4%, respectively. The initial investment for scenario 1 was €2290.5, €859.0 for scenario 2 and €3149.5 for scenario 3; the annual water bill reduction was €7115.4, €11,518.1, and €17,655.9, respectively. Therefore, the turnover of the investment was four (scenario 1), one (scenario 2), and three months (scenario 3). The filter washings attained the required standard for irrigation after being subjected to 15 h of sedimentation.

water efficiency | indoor municipal swimming pools | economic viability | filter washings reuse

1. Introduction

It is generally known that the ecological services provided by aquatic ecosystems and the water industry are facing increasingly complex challenges: the demand for water is continuously rising, causing the rapid exhaustion of existing water resources. Urban population growth and changing lifestyles, implying more intensive water use [1] and increasing water pollution [2], are the leading causes of this phenomenon. Besides, future climate changes will involve higher temperatures and changes in the intensity and patterns of precipitation, leading to more frequent droughts, as well as reducing water quantity and quality, in southern Europe and the Iberian Peninsula [3][4]. Thus, the urban water cycle is affected by climate change, but it is also contributing to climate change. Indeed, water potabilization processes, the delivery of water to consumers, and the treatment of wastewater use significant amounts of energy, contributing to increasing CO_2 and other greenhouse gas emissions [1][5][6]. Therefore, in the face of this scenario, it is important to implement water sustainability, promoting water use efficiency by reducing water consumption through the adoption of efficient products or devices (e.g., taps and showers), reducing waste and losses, and by reusing and recycling water [7]. Public indoor swimming-pool facilities use large amounts of water and, consequently, energy, because of their particular characteristics: (1) the relatively high temperature and humidity levels in the pool room; (2) the evaporation caused by pool usage; (3) the use of warm water for pools and showers; and (4) the requirement of a water treatment system [8][9]. Furthermore, users' number and behavior, the variety of services provided, the operating patterns [8][9], and the quality of indoor water and air [10][11] also influence the aforementioned characteristics. Nevertheless, to our best knowledge, research concerning the impact of these facilities on urban water demand is scarce. Some research has focused on residential swimming pools, revealing that pools have a very high impact on urban water demand and consequently on ecological integrity and the services provided by freshwater ecosystems [12][13][14][15]. However, approaches concerning municipal and public indoor swimming pools are even scarcer and, in some cases, very preliminary [16][17][18][19]. Similarly, research concerning the recycling and reuse feasibility of pool filter backwashing is also very scarce [20][21][22][23][24]. Therefore, to contribute to filling this information gap, the aim of this research is: (a) to determinate the water demand of a municipal indoor swimming pool complex; (b) to propose water use efficiency measures, analyzing their feasibility and costs; (c) to evaluate the possibility of recycling and reusing the water from swimming-pool filter backwashing.

Municipalities may use the results of this study to implement and improve measures to achieve greater water use efficiency in their infrastructure.

2. Current Insights

The approach discussed in this study showed that it is possible to promote a substantial increase in water efficiency in this facility by simply increasing the efficiency of water use for sanitary and hygienic purposes. As in other swimming pool facilities, the showers demonstrated the highest water consumption [1][8][9][19][25]. Therefore, the proposed measures, if implemented, will reduce the financial burden and increase the environmental benefits associated with water use. Herein, the energy consumption under the scope of the water–energy nexus was not evaluated. However, several authors describe large amounts of energy consumption due to excessive water use in residential or public buildings [1][6][7][26][27][28][29]. According to data obtained by [7], each cubic meter of water consumed implies the consumption of 1.115 kWh in the water supply system and the consumption of 0.818 kWh in drainage treatment and wastewater treatment processes, adding up to a total of 1.933 kWh. Therefore, assuming similar levels of energy consumption in the Bragança region, it is plausible to admit that the water consumption reductions predicted in each scenario would lead to energy savings in the public system ranging from around 2562.96 to 6532.52 kWh/year. Consequently, the turnover and the earnings for the different studied scenarios are monetarily and environmentally much higher than the estimates obtained herein. Indeed, implementing inexpensive and straightforward water efficiency measures (substituting showers and taps with more efficient devices) is also an essential step to improving energy efficiency while simultaneously reducing the waste of water, CO_2, and other greenhouse gas emissions.

The results concerning water consumption in pools (**Table 1**) are underestimates because they do not include the water losses caused by evaporation, swimmers exiting the pool, and water splashes. The authors of [25] demonstrated that an indoor heated 300 m^2 pool can lose 21,000 L of water per week through evaporation (water temperature: 28 °C, air temperature: 29 °C, and air humidity: 60%). Indeed, the water consumption in an indoor swimming pool, excluding sanitary and hygienic requirements, can reach 160 L/person per day, and the energy used is reported to be between 400 and 1600 kWh/m^2 of the usable area [9][25]. In general, indoor swimming pools use two types of energy sources: (1) thermal energy for showers, pool water, and space heating (the most significant portion of energy consumption); and (2) electricity to power water pumping systems, lighting systems, rotating equipment, air cooling, dehumidifying processes, and water treatment systems [19]). In Bragança swimming pools, natural gas boilers are the equipment used for producing hot water. According to information provided by the municipality concerning the period from 2018–2019, the mean annual value of natural gas consumption in the swimming pool's facilities was 719 KWh/m^2 (the data concerning electricity consumption were not available). The most frequent water and energy saving measure is the application of a cover over the water's surface during periods in which the facility is not in use, allowing the reduction of water evaporation [19] and the release of volatile disinfection by-products that negatively affect indoor air quality, often causing eye irritation or even asthma in users [11][30]. Additionally, this measure reduces air humidity, reducing the need for dehumidifying procedures and water reposition, which results in lower water and energy consumption levels. Efficiency measures affecting the filter flow rates, preventing good water mixing by creating zones in which water cannot circulate, should be avoided because of users' health and safety [11][31].

Table 1. Proposed scenarios for reducing water expenditure in the Bragança municipal swimming pool complex.

Scenarios	Measures
1	− Flushing cistern volume adjustment − Replacement of washbasin and kitchen taps
2	− Flushing cistern volume adjustment − Replacement of showers
3	− Flushing toilet volume adjustment − Replacement of washbasin and kitchen taps − Replacement of showers

Regular swimming pool filter backwashing is unavoidable due to the need to remove the contaminants accumulated during the filtration process and to condition the filter beds for continued efficient operation [32]. Nevertheless, this process generates large amounts of water, which may constitute 20% to 70% of the total facility wastewater volume discharged into the sewage contributing to water (and energy) use inefficiencies and environmental contamination [24]. Therefore, it is crucial to promote the sustainable management of backwashed water. The preliminary results showed that this water could not be directly reused for irrigation because of its high concentration of TSS, free residual chlorine, and turbidity. However, the sedimentation process seemed to effectively reduce these parameters to permissible values, allowing the reuse of this water for irrigation purposes or for flushing cisterns, according to the parameters proposed in the available regulation [33][34][35]. Similar trends were found by [21][22][23][24]. Furthermore, these authors also verified that the sedimentation process was effective in removing nitrogen and phosphorus. Therefore, considering these results, it is plausible to assume that the management of filter washings is possible in this facility after the installation of a relatively simple system for their treatment, such as a settler or a settling tank. Furthermore, considering that the annual amount of water necessary for irrigating the lawn of the local football stadium, located in the surroundings of the swimming pool complex, is around 7200 m^3 (data provided by municipality), the backwashed water could be fully reused for this purpose. Nevertheless, the treated filter backwashing could also be used in the flushing cisterns or, after a broader treatment, reintroduced back into the swimming pool [32]. However, due to the lack of specific legislation for backwashing monitoring and quality control, other indicators such as nutrients, micropollutants, and other chlorine forms [32][36] should be determined in future approaches.

3. Conclusions

Under a climate change scenario, the improvement of water use efficiency is paramount. The present study obtained valuable information about the feasibility of promoting water efficiency in public swimming pools by implementing simple and relatively inexpensive, cost-effective measures, significantly reducing water consumption without jeopardizing users' comfort and health. Besides, the possibility of reusing the backwashed water increases water and energy efficiency even further. Furthermore, the methodology used in the present approach is easily replicated, allowing its application in any swimming pool complex. Nevertheless, future approaches are needed to: (1) determine the—water–energy nexus with more accuracy for this building to plan and manage the water and energy in an integrated manner, since there is an intrinsic link between both items; (2) to evaluate the feasibility of reusing the filter washings for irrigation and, eventually, for other purposes, in terms of the water–energy nexus, water quality, and investment turnover; and (3) develop educational measures to promote users' awareness of the importance of water and energy efficiency.

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