Article

Assessment of Measures to Increase Water Efficiency in Public Swimming Pools

Carla Pimentel-Rodrigues 1,2,3,* and Armando Silva-Afonso 2,4

1 ISCIA—Higher Institute of Information and Administration, 3810-488 Aveiro, Portugal
2 ANQIP—National Association for Quality in Buildings Services, 3810-193 Aveiro, Portugal
3 Department of Civil Engineering, University of Aveiro, 3810-193 Aveiro, Portugal
4 RISCO—Research Center for Risks and Sustainability in Construction, Department of Civil Engineering, University of Aveiro, 3810-193 Aveiro, Portugal
* Correspondence: anqip@anqip.pt; Tel.: +351-234-092-597

Abstract: Situations of water stress or even water scarcity are becoming frequent in many regions of the planet, due to the exponential increase in population, the economic development model, and/or climate change. An example of a region where climate change is causing increasing situations of water stress is southern Europe, in the Mediterranean basin. One of the countries where this situation is becoming evident is Portugal, especially the center and south of the country, which has led the government to promote legislation or support for more efficient use of water in different sectors. In the case of the urban sector, local authorities, which are responsible for public water supply, have sought to promote specific actions for the conservation of drinking water and water efficiency measures in buildings and public spaces, in addition to other measures to raise awareness of the consumers. In this article, two technical measures proposed for public swimming pool complexes in the municipality of Cascais are analysed, aiming at greater efficiency in the use of water and the use of alternative sources for non-potable uses. These measures involved carrying out water efficiency audits at the facilities and a feasibility study on the use of the volumes of daily water renewal in swimming pools, for non-potable uses, specifically for flushing toilets. The results show that, in addition to their significant contribution to greater water efficiency in urban areas, these measures are also interesting from an economic point of view, also contributing to a reduction in greenhouse gas emissions.

Keywords: climate change; public swimming pools; water efficiency; water reuse

1. Introduction

Population growth, the economic growth model and/or climate change explain the problems of water stress or even water scarcity that are progressively being observed in many regions of the planet [1,2]. In the case of mainland Europe, for example, droughts are increasingly frequent and intense, especially in the south, with climate change being considered mainly responsible for the situation [3,4].

Climate change is currently a clear reality and, in the future, it will progress according to several possible scenarios, which will depend on the mitigation measures that are implemented by world governments in the short/medium term [3,5,6]. As a result of this climate change, a change in weather patterns will occur in many regions, and extreme weather events will be more frequent and intense in the coming decades and will result in a higher incidence of floods and droughts across the planet [7].

Variations due to climate change in the characteristics of precipitation and drought will differ from region to region of the planet, with precipitation increasing in high-latitude regions and decreasing in most subtropical areas [8,9]. About mainland Europe, southern and central Europe will experience increasingly frequent heat waves and
droughts. The Mediterranean basin, in particular, will gradually become drier and more vulnerable to droughts [10–12].

About 54% of the planet’s population currently lives in cities, but this percentage is expected to increase to 66% by 2050 according to the United Nations. Therefore, the impact of climate change on urban environments will be very significant, forcing measures to improve adaptation and greater resilience to more extreme climatic conditions [13,14]. In cities, prolonged droughts can create interruptions in the public supply of water to populations and activities, with very significant impacts [15,16].

Thus, within the scope of the action to be developed in urban environments in the fields of adaptation to climate change, the efficient use of drinking water should receive particular attention in many regions, as well as the recourse to alternative sources for non-potable purposes [17–23]. This is particularly important concerning the Mediterranean basin, as mentioned above, where the reduction in precipitation is expected to be very significant, along with a significant increase in average annual temperatures. Bearing in mind the water-energy nexus, it can be concluded that interventions within the scope of greater water efficiency in urban areas also translate into contributions to the reduction of energy consumption, that is, to the mitigation of emissions [24].

This article assesses the potential for increasing water efficiency in public swimming pool complexes in Portugal, through the reuse of daily renewal water of the swimming pool to supply flushing cisterns in toilets, and also through intervention in existing devices in the buildings of the sports complex. It should be noted that the daily renewal of water in public swimming pools, in a proportion between 2 and 3% of the pool’s total volume, is mandatory in Portugal, similarly to what happens in other countries, in accordance with applicable national and European standards.

There are few studies in this field [25–27], but a recent article concerning research in the north of Portugal (Bragança), in the same context of increasing water efficiency in municipal swimming pools, should be highlighted. In this last study, however, diverse types of interventions are analysed, such as the possibility of reusing filter washing water and the replacement of taps and washbasins with more efficient ones [28].

For the present study, three municipal swimming pools in Portugal were studied. These pools, with different characteristics, are located in the municipality of Cascais, close to the country’s capital (Lisbon), in a region influenced by a Mediterranean climate and with significant predictions forecast for water stress in the short/medium term. Figure 1 shows images of the three selected swimming pool complexes (Abóboda, Alcabideche, and Alapraia).
In general terms, this article describes an experimental research, in the area of engineering, providing experimental and methodological details for the reuse of water in public swimming pools, so that these solutions can be reproduced and evaluated, aiming at greater sustainability in the use of drinking water.

2. Materials and Methods

The present study focuses on two measures that are considered to have potential technical-economic feasibility in public swimming pools to increase their water efficiency: intervention in washbasin taps, showers, and flush toilets, aiming at reducing the flow rates or volumes used, and reclamation of the volumes that are discharged to comply with legal requirements for daily renovation of water in public swimming pools, to feed flushing cisterns.

Two days a week, the renewal water discarded on those days is used for backwashing of filters, which affects the characteristics and quality of the final discharge. On the remaining days of the week, 2% to 3% volume is discarded directly to simply comply with legal water renewal requirements. For this reason, in the present study, only the use of 5/7 of all the water discarded will be considered.

Table 1 summarises the characteristics of the pools integrated into the three sports complexes selected for the present study, which are open to the public every day of the week. It should be noted that, in the case of the swimming pool complexes of Abóboda and Alapraia, there are also other smaller pools, intended, for example, for hydro gymnastics and swimming lessons for children, which were not considered in the present study.

Table 1. Characteristics of the swimming pool.

| Characteristics              | Abóboda | Alcabideche | Alapraia |
|-----------------------------|---------|-------------|----------|
| Length (m)                  | 25.00   | 16.66       | 25.00    |
| Width (m)                   | 17.00   | 10.00       | 17.00    |
| Maximum depth (m)           | 2.00    | 1.40        | 1.65     |
| Minimum depth (m)           | 1.80    | 0.90        | 1.30     |
| Total volume (m³)           | 808.00  | 184.00      | 600.00   |
| Volume renewed daily (m³)   | 16.16   | 3.68        | 12.00    |
| Water percentage renewed daily | 2%      | 2%          | 2%       |
The discharge of daily pool water renewal volumes is done manually in all three cases, with control through the reading of totalising flow meters installed in the equipment room. Figure 2 shows an example of a flow meter installed in one of the sports complexes, which allows the discharged flow to be measured.

Concerning interventions in the installed devices, the swimming pool complexes essentially have washbasin taps, showers, urinals, and flush toilets, and these devices are similar in all the sports facilities. However, the urinals were not considered in this study, as they are equipped with flush valves, regulated with reduced opening times (4 to 5 s), and relatively low factory flow rates, which do not justify an intervention.

Regarding the washbasin taps (Figure 3), the application of flow reducers was considered. It should be noted that, in Portugal, reducers for taps are tested and certified by a non-governmental association of the sector (ANQIP—National Association of Quality in Building Installations), which prepares and provides flow–pressure curves for various reducers available on the market, thus allowing the choice of the most convenient models depending on the local pressure and the desired flow rates. The proper flow rates at the washbasin taps are set considering the water efficiency labelling scheme existing in Portugal, also under the responsibility of ANQIP (Figure 4), considering the values corresponding to category A (4 L/min) [29].
When the taps are of the self-closing type (Figure 3), there is another possible intervention aiming at an increase in water efficiency, which is the regulation of the opening time when it is excessive. However, it was found that, in all situations, the opening times were close to 8 s, a value considered acceptable, so this intervention was not considered further. It should be noted that the ideal opening times are generally between 6 and 8 s and that lower values are not advisable, as they lead to successive actuations [30].

For showers, the reference value for category A of the ANQIP water efficiency labelling scheme is 8 L/min, noting that, in one of the pools (Abóboda), the products installed already meet this value. These showers are of the self-closing type (Figure 5), with opening times of 30 s, a value that was considered adequate and was not subject to intervention. In the remaining installations, the application of certified flow reducers was foreseen.

Regarding flushing cisterns in toilets, most of the models installed are of single flush (or complete discharge) and have a volume of 10 L (Figure 5). The feasibility of reducing
the volumes to those corresponding to category A of the ANQIP labelling scheme (dual flush 3/6 L) was confirmed, by simply replacing the internal flushing mechanisms with universal and adjustable ones, available on the market.

Table 2 summarises the main characteristics of the washbasin taps, showers, and flushing cisterns at the three sports complexes. The average flow rates indicated for the taps and showers correspond to an average of the values determined with analogic and/or digital flowmeters (Figure 6).

| Characteristics                        | Abóboda          | Alcabideche     | Alapraia         |
|----------------------------------------|------------------|-----------------|------------------|
| Number of washbasin taps (units)       | 38               | 8               | 25               |
| Type of washbasin taps (-)             | 7 single lever   | Self-closing    | 3 single lever   |
|                                        | and 31 self-closing |                 | and 22 self-closing |
| Average flow rate on taps (L/min)      | 7.18             | 6.14            | 6.87             |
| Number of flush toilets (units)        | 32               | 9               | 26               |
| Type of flushing cisterns (-)          | Single flush     | Single flush    | 8 dual flush and 18 single flush |
| Average volume (L)                     | 10.0             | 10.0            | 10.0             |
| Number of showers (units)              | 41               | 15              | 33               |
| Type of shower (-)                     | Fixed shower head, self-closing | Hand-held shower head | Hand-held shower head |
| Average flow rate on showers (L/min)   | 8.00             | 14.29           | 12.60            |

3. Results and Discussion

3.1. Reduction of Consumption

In order to assess the expected reductions in consumption and make a technical-economic assessment of the proposed measures, it is necessary to estimate the percentages of water consumption allocated to each type of use. For this purpose, average values resulting from studies carried out in public swimming pools in Portugal [31] were considered (Table 3). The annual consumption values indicated in the Table are average values provided by the municipality of Cascais for the pre-COVID-19 pandemic period, given that, during the pandemic period, there was under-occupation of the pools and even periods of partial closure.
Table 3. Average annual consumption in the swimming pools.

| Use                           | Percentage of Use [21] | Average Annual Consumption (m³) |
|-------------------------------|------------------------|--------------------------------|
|                               |                        | Abóboda | Alcabideche | Alapraia |
| Toilets (flushing cisterns)   | 7.5%                   | 1789.20 | 604.56      | 712.32   |
| Washbasin taps                | 7.5%                   | 1789.20 | 604.56      | 712.32   |
| Urinals                       | 1.5%                   | 357.84  | 120.96      | 142.44   |
| Showers                       | 41.0%                  | 9780.96 | 3304.92     | 3893.76  |
| Cleaning and other uses       | 13.5%                  | 3220.56 | 1088.16     | 1282.08  |
| Pool tanks                    | 29.0%                  | 6918.24 | 2337.60     | 2754.12  |
| **Total**                     | 100%                   | 23,856.00 | 8060.76 | 9497.04 |

The following table (Table 4) presents, for the three pool complexes, an analysis of the estimated reduction in consumption with the interventions foreseen in the devices. In these calculations, for double flush toilets, the average value of flushes (4.5 L) was assumed, i.e., an equal number of full flushes and half flushes is considered. Since the devices are all similar, it is not necessary to consider the existence of differences in the intensity of use of the different devices.

Table 4. Reduction of consumption foreseen in the Abóbada, Alcabideche, and Alapraia swimming pools.

| Swimming Pool | Device                          | Weighted Average Reduction | Current (Annual) | Reduction (Annual) | Reduction (Monthly) |
|---------------|---------------------------------|-----------------------------|------------------|--------------------|--------------------|
| Abóbada       | Toilets (flushing cisterns)     | (10.0 - 4.5)/10.0 = 55.0%  | 1789.20          | 984.06             | 82.00              |
|               | Washbasin taps                  | (7.2 - 4.0)/7.2 = 44.4%    | 1789.20          | 794.40             | 66.20              |
|               | Showers                         | 0%                          | 9780.96          | 0                  | 0                  |
| Alcabideche   | Toilets (flushing cisterns)     | (10.0 - 4.5)/10.0 = 55.0%  | 604.56           | 332.51             | 27.71              |
|               | Washbasin taps                  | (6.1 - 4.0)/6.1 = 34.4%    | 604.56           | 207.97             | 17.33              |
|               | Showers                         | (14.3 - 8.0)/14.3 = 44.1%  | 3304.92          | 1457.47            | 121.46             |
| Alapraia      | Toilets (flushing cisterns)     | (18/26) (10.0 - 4.5)/10.0 = 38.1% | 712.32          | 271.39             | 22.62              |
|               | Washbasin taps                  | (6.9 - 4.0)/6.9 = 42.0%    | 712.32           | 299.17             | 24.93              |
|               | Showers                         | (12.6 - 8.0)/12.6 = 36.5%  | 3893.76          | 1421.22            | 118.44             |

Table 5 summarises the main results obtained, highlighting the short payback periods of these interventions. These payback periods were obtained based on the values of monthly savings (considering the applicable water tariff of the Municipality of Cascais, which varies according to the echelon of consumption and the characteristics of the concessionaire of the facility) and the investments necessary in each case, according to estimates prepared by the Municipality of Cascais.

Table 5. Reduction of consumption in taps and flushing cisterns. Results of the technical–economic analysis.

| Parameters                          | Swimming Pool       |
|-------------------------------------|---------------------|
| Total monthly savings (m³)          | Abóboda | Alcabideche | Alapraia |
| (A)                                 | 148.20             | 166.50      | 165.99   |
| Applicable water price (€/m³)       | (B)                | 1.23        | 2.47     | 1.68     |
| Total monthly savings (€)           | (C = A × B)        | 182.29      | 411.26   | 278.87   |
| Total investment (€)                | (D)                | 1020.90     | 455.10   | 1002.45  |
| Current monthly consumption (m³)    | (E)                | 1988.00     | 671.73   | 791.42   |
| Total savings (%)                   | (F = A/E)          | 7.5         | 24.8     | 21.0     |
| Payback period (months)             | (G = D/C)          | 5.6         | 1.1      | 3.6      |
In Portugal, the type of energy used in the public water supply and drainage systems is exclusively electricity and a recent study [32] indicates a unit value of 1.98 kWh/m³. Based on this number, the energy savings resulting from the water efficiency measures proposed are also indicated in Table 5.

According to the main power operator in Portugal (EDP), commercialised electricity is produced from a mixture of sources, including hydro, coal, wind, nuclear, natural gas and others (including national production and imports) and the most significant contribution to greenhouse gases (GHG) emissions corresponds to CO₂ emissions (other gases such as SO₂ or NOₓ have a negligible contribution). At the time of this study, these emissions were weighted as 269 g/kWh, and this indicator also allows an estimate of the reductions in greenhouse gas emissions resulting from this intervention, as shown in Table 5.

### 3.2. Reuse of the Volume of Daily Water Renewal in Swimming Pools to Flush Toilets

Unlike water from filter backwashing, the daily direct discharges for water renewal in swimming pools do not have any additional pollution, maintaining their characteristics of contact or bathing water and levels of disinfectant (generally chlorine) higher than those usually present in the water mains. The water of swimming pools with these characteristics is relatively unpolluted, although it may, however, have some hair, skin particles and, possibly, other dirt. Thus, its use in flushing toilets with elementary precautions (a hair filter, for example) does not appear to present any health problem, unless this water remains stored for long periods, with deterioration of its quality. However, the analytical results obtained by some authors in relation to filter backwashing water with sedimentation [18] lead to the conclusion that storage periods of a few days are not problematic for this water.

It should be noted that short storage periods are required when the availability of water is greater than the needs in the same period and the tank can be designed with a volume that does not exceed these needs. These conditions are met in these three swimming pools, as will be seen later. In any case, the adequate maintenance of the equipment plays an important role in the health security of the solution, as is normal.

In the case of the reuse of grey water, it is mentioned in [32] that the substances present in the water are usually the result of personal hygiene products, detergents, hair, skin, dandruff particles and, possibly, dirt from clothes, being easily biodegradable. Due to this biodegradability, the treatment cannot be delayed too long as decomposition processes involving sulphates and unpleasant smells can be triggered (shampoos, conditioners, face washes, toothpastes, etc. contain sulphates). However, in the case of swimming pools, it is assumed that there are no hygiene products or detergents, for example, in the water.

In terms of water availability, Table 1 summarises the daily values discharged in each of the pools. As previously mentioned, only 5/7 of the total amount will be considered, since on two days of the week (non-consecutive) the water will be used for backwashing the filters, for which Table 6 indicates the maximum availability to consider. It should be noted that the volume of the tank that supplies the toilets must have, in principle, a volume sufficient for two days.
In terms of needs, taking for example the Abóboda pool complex, from Table 4 it can be determined that the water needed to flush toilets is:

\[
(1789.20 - 984.06) = 805.14 \text{ m}^3/\text{year} = 2206 \text{ L/day}
\]  

This value can be confirmed based on the average number of users of the swimming pool (which, according to the Municipality of Cascais, was 494 users/day in the pre-pandemic period) and considering an average value of one use per person. In fact, in men’s locker rooms, where urinals are installed, the use of toilets will probably be lower, but in women’s locker rooms, the use will probably be higher. Thus, the unit value is considered to be an acceptable estimate.

Assuming the average value per flush of 4.5 L, a daily volume can be obtained of:

\[
494 \times 4.5 \times 1 = 2223 \text{ L/day}
\]  

This value agrees with the previous one, so it is considered that a 5000-L tank will be enough to satisfy the water needs for two days, even considering a gap for a possible peak of use.

Table 6 summarises the values obtained for the three swimming pool complexes. As can be seen, the needs are much lower than the availabilities in all cases.

### Table 6. Values to consider in the use of water renewal discharges from swimming pools to flush toilets.

| Characteristics                                      | Abóboda | Alcabideche | Alapraia |
|-------------------------------------------------------|---------|-------------|----------|
| Volume renewed daily (m³)                             | 16.16   | 3.68        | 12.00    |
| Water percentage renewed daily                        | 2%      | 2%          | 2%       |
| Maximum availability possible (m³/day)                | (5/7) × 16.6 = 11.54 | (5/7) × 3.68 = 2.63 | (5/7) × 12.00 = 8.57 |
| Maximum availability possible (L/day)                 | 11,540  | 2630        | 8570     |
| Water needed to flush toilets (m³/year) (from Table 1)| 805.14  | 272.05      | 440.90   |
| Water needed to flush toilets (L/day) (from Table 1)  | 2206    | 745         | 1208     |
| Average number of users (users/day)                   | 494     | 180         | 250      |
| Water needed to flush toilets (L/day) (2)             | 494 × 4.5 × 1 = 2223 | 180 × 4.5 × 1 = 810  | 250      |
| Water needed (combining 1 and 2) (L/day)              | 2500    | 750         | 1250     |
| Volume adopted for the tanks (L)                      | 5000    | 1500        | 2500     |

Small hydropneumatic pumping groups should be installed next to the tanks, guaranteeing the pressures and flows necessary to supply the toilets. The tanks, prefabricated in HDPE, will be equipped with excess water discharge (overflow). On the other hand, in order to promote the emptying of the tanks for periodic cleaning and maintenance actions, bottom drains must be installed and the possibility of inspection of the interiors must be guaranteed through the respective caps.

A system of isolating valves must also be provided upstream of the tanks, so that the systems can be connected/disconnected in the event of anomalies being detected or for their maintenance. Systems should also be considered for the eventual supply of the tanks.
with water from the public water supply system, with anti-pollution prevention in accordance with EN1717:2000.

Based on the investments required in each case (pipes and accessories for supplying the tanks, for feeding the flush toilets and for drains, pressurisation equipment, electrical installations, etc.) the Municipality of Cascais prepared estimates of the necessary investments, from which the respective payback periods were calculated. The summarised values are shown in Table 7.

**Table 7.** Use of discharged water for daily water renewal in swimming pools to flush toilets. Results of the technical–economic analysis.

| Parameters                                      | Swimming Pool |   |   |
|------------------------------------------------|---------------|---|---|
|                                                | Abóboda       | Alcabideche | Alapraia |
| Total daily savings (L/day)                    | 2206          | 745          | 1208     |
| Total annual savings (m³/year)                 | 805.19        | 271.93       | 440.92   |
| Applicable water price (€/m³)                  | 1.23          | 2.47         | 1.68     |
| Total annual savings (€)                       | 990.39        | 671.65       | 740.75   |
| Total investment (€)                           | 5200.00       | 3800.00      | 4300.00  |
| Payback period (years)                         | 5.3           | 5.7          | 5.8      |

The results obtained (resumed in Table 8) reveal, in all cases, small payback periods between 5 and 6 years, values that can be considered very interesting considering the useful life of these solutions, in the order of 20 years. It should be noted that the calculation of return periods is done in a simplified way, not considering update rates, annual operating or maintenance costs or water or energy price variations, but it is considered that this simplification does not invalidate the result, since the values in question are in the order of a few years.

**Table 8.** Results of the application of the proposed water efficiency measures for swimming pools.

| Parameter                                      | Swimming Pool |   |   | Total |
|------------------------------------------------|---------------|---|---|-------|
|                                                | Abóboda       | Alcabideche | Alapraia |       |
| Measure 1                                      |               |             |           |       |
| Annual water savings (m³)                      | 1778.40       | 1998.00     | 1991.88   | 5768.28 |
| Annual savings (€)                             | 2187.48       | 4935.12     | 3346.44   | 10,469.04 |
| Total investment (€)                           | 1020.90       | 455.10      | 1002.45   | 2478.45 |
| % of water savings (%)                         | 7.5           | 24.8        | 21.0      | -      |
| Medium payback period (years)                  | -             | -           | -         | 0.24   |
| Annual energy savings (kWh)                    | 3521.23       | 3956.04     | 3943.92   | 11,421.19 |
| Reduction in GHG emissions (kg/year)           | 927.21        | 1064.17     | 1060.91   | 3052.29 |
| Measure 2                                      |               |             |           |       |
| Annual water savings (m³)                      | 805.19        | 271.93      | 440.92    | 1518.04 |
| Annual savings (€)                             | 990.39        | 671.65      | 740.75    | 2402.79 |
| Total investment (€)                           | 5200.00       | 3800.00     | 4300.00   | 13,300.00 |
| Medium payback period (years)                  | -             | -           | -         | 5.53   |
| Measure 1 + Measure 2                          |               |             |           | 5.53   |
| Annual water savings (m³)                      | 2.583.59      | 2269.93     | 2432.80   | 7,286.32 |
| Annual savings (€)                             | 3.177.87      | 5606.77     | 4087.19   | 10,469.04 |
| Total investment (€)                           | 1020.90       | 455.10      | 1002.45   | 12,871.83 |
| Medium payback period (years)                  | -             | -           | -         | 1.23   |

In the current context of high inflation in many countries, including Portugal, the payback period tends to be prolonged, if there is no intervention in other parameters such
as the price of water. However, the Portuguese Government considers the possibility of increasing the price of water in the short term, so the increase in the payback period may not be relevant.

4. Conclusions

As mentioned earlier, this article describes an experimental research, providing experimental and methodological details for the reuse of the daily renewal water in public swimming pools, so that these types of solutions can be reproduced and evaluated, aiming at greater sustainability in the use of drinking water.

Dealing with climate change is one of the major challenges facing mankind in the 21st century. In some parts of the world, such as the Mediterranean basin, one of the likely effects of climate change will be the worsening of the severity and duration of droughts, which recommends that water management be done by reducing demand. In urban environments, water efficiency and potable water conservation solutions must therefore be priority measures.

In this article, two different typologies of measures of water efficiency applicable to public swimming pools are evaluated, which, with relatively low investment costs and very short payback periods, allow significant reductions in drinking water consumption, as can be seen in the summary in Table 8. Measure 1 aims to reduce consumption through interventions in the devices (application of reducers in taps and replacement of flushing mechanisms in toilets) and Measure 2 provides for the use of discharged water for daily water renewal in swimming pools to flush toilets.

Measure 1, in addition to its obvious contribution to adapting to climate change in cities, also contributes to the reduction of energy consumption in the urban water cycle, as an outcome of the water-energy nexus. Thus, it allows a reduction in the emission of greenhouse gases, also contributing to the mitigation of climate change. Regarding the reduction of energy consumption and GHG emissions with Measure 2, no results are presented, as these reductions can be annulled by the need to pressurise the water to feed the flush toilets [17].

In global terms, the total annual water savings from the public network are 7286.32 m³, which corresponds to the consumption of 158 inhabitants, considering the average per capita value in Portugal of 127 L/(inhabitant and day), that is, 46 m³/(inhabitant and year). Considering the current average total annual water consumption of the three pools (41,424.36 m³, as can be taken from Table 5), the estimated total savings in drinking water of 7286.32 m³ correspond to a reduction in consumption of 17.6%, a value that is considered very significant.

Author Contributions: The authors made similar contributions to the development of the article. Conceptualization, A.S.-A.; Methodology, A.S.-A. and C.P.-R.; Validation, A.S.-A. and C.P.-R.; Formal analysis, A.S.-A.; Investigation, A.S.-A. and C.P.-R.; Writing—original draft preparation, C.P.-R.; Writing—review and editing, A.S.-A. and C.P.-R.; Supervision, A.S.-A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors are grateful for the technical collaboration of the Municipality of Cascais (Portugal) in providing base elements and cost estimates.

Conflicts of Interest: The authors declare no conflict of interest.
References

1. Ma, T.; Sun, S.; Fu, G.; Hall, J.W.; Ni, Y.; He, L.; Yi, J.; Zhao, N.; Du, Y.; Pei, T.; et al. Pollution exacerbates China’s water scarcity and its regional inequality. Nat. Commun. 2020, 11, 650.

2. Kundzewicz, Z.W.; Mata, L.J.; Arnell, N.W.; Döll, P.; Jimenez, B.; Miller, K.; Oki, T.; Sen, Z.; Shiklomanov, I. The implications of projected climate change for freshwater resources and their management. Hydrol. Sci. J. 2008, 53, 3–10.

3. Chalmers, P. Climate Change. Implications for Buildings. Key Findings from the Intergovernmental Panel on Climate Change, Fifth Assessment Report; European Climate Foundation, Building Performance Institute Europe, Global Buildings Performance Network, World Business Council for Sustainable Development, University of Cambridge’s Judge Business School, Institute for Sustainability Leadership; BPIE: Brussels, Belgium, 2014.

4. Spinoni, J.; Vogt, J.V.; Naumann, G.; Barbosa, P.; Dosio, A. Will drought events become more frequent and severe in Europe? Int. J. Climatol. 2018, 38, 1718–1736.

5. United Nations. World Urbanization Prospects; The 2014 Revision (Highlights); United Nations—Department of Economic and Social Affairs: New York, NY, USA, 2014; ISBN 978-92-1-151517-6.

6. Ribeiro, J.M.P.; Bocasanta, S.L.; Ávila, B.O.; Magoto, M.; Jonck, A.V.; Gabriel, G.M.; Guerra, J.B.S.O.D.A. The adoption of strategies for sustainable cities: A comparative study between Seattle and Florianopolis legislation for energy and water efficiency in buildings. J. Clean. Prod. 2018, 197, 366–378.

7. Wilk, J.; Wittgren, H. Adapting Water Management to Climate Change; Swedish Water House Policy Brief 2009, Nr. 7; SIWI: Stockholm, Sweden, 2009.

8. Haines, A.; Kovats, R.; Campbell-Lendrum, D.; Corvalan, C. Climate change and human health: Impacts, vulnerability and public health. Public Health 2006, 120, 585–596.

9. Trenberth, K. Changes in precipitation with climate change. Clim. Res. 2011, 47, 123–138.

10. AWWA. Climate Change and Water Resources: A Primer for Municipal Water Providers; AWWA Research Foundation, University Corporation for Atmospheric Research, American Water Works Association; IP-SC-91120-05/06-NH; IWA Publishing: Denver, CO, USA, 2006.

11. Magadza, C. Climate change impacts and human settlements in Africa: Prospects for adaptation. Environ. Monit. Assess. 2000, 61, 193–205.

12. World Health Organization. Summary and Policy Implications Vision 2013: The Resilience of Water Supply and Sanitation in the Face of Climate Change; WHO—Department for International Development: Geneva, Switzerland, 2009; ISBN 978-92-4-159842-2.

13. Giorgi, F.; Lionello, P. Climate change projections for the Mediterranean region. Glob. Planet. Change 2007, 63, 90–104.

14. Pausas, J.G. Changes in fire and climate in the Eastern Iberian Peninsula (Mediterranean Basin). Clim. Change 2004, 63, 337–350.

15. European Commission. COM 718 Communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment; Commission of the European Communities—SEC: Brussels, Belgium, 2006; p. 16.

16. Wilby, R. A review of climate change impacts on the built environment. Built Environ. J. 2007, 33, 31–45.

17. La Licata, I.; Colombo, L.; Francani, V.; Alberti, L. Hydrogeological study of the glacial—Fluvio glacial territory of Grandate (Como, Italy) and stochastic modeling of groundwater rising. Appl. Sci. 2018, 8, 1456.

18. Dean, J.; Sholley, M. Groundwater Basin Recovery in Urban Areas and Implications for Engineering Projects. Engineering Geology for Tomorrow’s Cities; IAEG: Dublin, Ireland, 2006.

19. United Nations. Buildings and Climate Change: Summary for Decision-Makers; United Nations Environment Program: Paris, France, 2009; ISBN 987-92-807-3064-7.

20. UNEP. Technologies for Climate Change Mitigation: Building Sector; UNEP Riso Centre on Energy, Climate and Sustainable Development: Copenhagen, Denmark, 2012; ISBN 978-87-92706-57-7.

21. Hof, A.; Schmitt, T. Urban and tourist land use patterns and water consumption: Evidence from Mallorca, Balearic Islands. Land Use Policy 2011, 28, 792–804.

22. Fisher-Jeffes, L.; Gertse, G.; Armitage, N. Mitigating the impact of swimming pools on domestic water demand. Water SA 2015, 41, 238–246.

23. Morote, Á.-F.; Saurí, D.; Hernández, M. Residential Tourism, Swimming Pools, and Water Demand in the Western Mediterranean. Prof. Geogr. 2017, 69, 1–11.

24. Pimentel-Rodrigues, C.; Silva-Afonso, A. Contributions of water-related building installations to urban strategies for mitigation and adaptation to the climate change. Appl. Sci. 2019, 9, 3575.

25. Wyczarska-Kokot, J. The Study of Possibilities for Reuse of Washings from Swimming Pool Circulation Systems. Ecol. Chem. Eng. S 2016, 23, 447–459.

26. Łaskawiec, E.; Dudaż, M.; Wyczarska-Kokot, J. Assessment of the possibility of recycling backwashing water from the swimming pool water treatment system. Ecol. Chem. Eng. A 2016, 23, 401–410.

27. Wyczarska-Kokot, J.; Lempart, A. The reuse of washings from pool filtration plants after the use of simple purification processes. Arch. Civ. Eng. Environ. 2018, 11, 163–170.

28. Silva, F.; Antão-Geraldies, A.M.; Zavattieri, C.; Afonso, M.J.; Freire, F.; Albuquerque, A. Improving water efficiency in a municipal indoor swimming-pool complex: A case study. Appl. Sci. 2021, 11, 10530. https://doi.org/10.3390/app112210530.
29. Silva-Afonso, A.; Pimentel-Rodrigues, C. Water efficiency of products. The Portuguese system of certification and labeling. *Journal - American Water Works Association* **2010**, *102*, 52–56.

30. Rodrigues, F.; Silva-Afonso, A.; Pinto, A.; Macedo, J.; Silva-Santos, A.; Pimentel-Rodrigues, C. Increasing water and energy efficiency in university buildings: A case study. *Environ. Sci. Pollut. Res.* **2019**, *27*, 4571–4581; ISSN 0944-134; https://doi.org/10.1007/s11356-019-04990.

31. Silva-Afonso, A.; Pimentel-Rodrigues, C. *Manual de Eficiência Hídrica em Edifícios*; ANQIP: Aveiro, Portugal, 2017. (In Portuguese)

32. ANQIP (Associação Nacional para a Qualidade nas Instalações Prediais). Technical Specification ETA 0905:2009 (Sistemas Prediais de Reutilização e Reciclagem de Águas Cinzentas). Available online: https://anqip.pt/index.php/pt/comissoes-tecnicas/98-comissao-tecnica-0905 (accessed on 1 March 2022). (In Portuguese)