Research article

Water Reuse in a Municipal Sports Center

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Abstract.
Two potential measures for increasing water use efficiency in a municipal sports center were evaluated: (1) the reuse of water originating from showers in the flushing toilets in the indoor football court building; and (2) the reuse of water from swimming pool filter backwashing for irrigation. In the indoor football court building the total annual water consumption is around 3,500.5 m^3 and from the showers is approximately 1,785.26 m^3. Therefore, the greywater generated in showers can be reused in toilet flushing, which consumes about 840.12 m^3 per year. The estimated annual water consumption for filter backwashing is 4,197.6 m^3. The annual amount of water necessary for irrigating the lawn of the local football stadium is around 7,200 m^3. Thus, the filter backwashed water, after being subjected to a sedimentation process, could be fully reused for this purpose.

Keywords: water efficiency, water reuse, swimming pools filter backwashing reuse, sports center, sustainability

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1. Introduction

Water scarcity is one of the leading social and environmental problems faced by society. Consequently, there is a need to preserve water and search for alternative sources. The reuse of greywater (water flow originated from showers, hand basins, laundry, dish-washing) can be one of the solutions to achieve one of the major goals of urban sustainability: the water [1-4] and energy efficiency [5]. It has been estimated that about 41–91% of the domestic water use turns into greywater. In Europe, around 35–150 L/(person.day) of greywater is produced [1]. Greywater from laundry and kitchen are considered to have a high pollutant load [1], whereas the water from showers and hand basins has a low pollutant load [6]. Thus, the latter can be reused for flushing cisterns or gardening after simple treatments (e.g., filtration, sedimentation, and disinfection) since the water used for the mentioned purposes does not require potable quality water standards. In sports centers, around 72% of the water is used in showers (51%) and hand basins (21%) [7]. Therefore, it is of paramount importance to implement management measures to promote the reuse of this water in these large-area facilities where water consumption is usually high [4]. If these have simultaneously swimming pools, the pool filters backwashing also generate large amounts of water, which can, in turn, be reused [8]. Indeed, this process is required to remove contaminants accumulated during the pool filtration process. The filters are cleaned by flushing them with water in the reverse direction to normal flow (backwashing) [9]. The resulting backwash water is characterized by high contents of suspension and dissolved substances and, depending on the future application, requires differentiated treatment before being reused [8,10-11]. The Bragança municipal sports center has the following facilities (Fig.1): an indoor football court (building A), two indoor swimming pools (building B), and the local football stadium (C). In the present approach, two potential measures for increasing water use efficiency in this building were evaluated: (1) the reuse of water originated from showers in the flushing toilets in building A, and (2) the reuse of water from swimming pools filters cleaning for irrigation.

Figure 1: Plan of the Bragança municipal sports center: indoor football court (A) pools (B) and football stadium (C) (source: Google Earth).

2. Material and methods

According to the information provided by the municipality, the average number of users/year in building A was 36,873 (128 users per day) from 2016-2018. In the present approach, because of the COVID-19 pandemic, it was impossible to measure ”in-situ” the different water uses. Therefore, these were estimated based on audits carried out by ANQIP (Portuguese Association for Quality and Efficiency in Building Services) for water use in sports centers [7]. The amount of water necessary to backwash the swimming pool sand filters (Table 1) was quantified by registering the values of the water flow meter immediately before and after the backwashing process. Swimming pool filters are rinsed every two days for five minutes. After, the backwashed water is discharged into the wastewater drainage network.

To evaluate the quality of backwashed water and, therefore, the possibility of its reuse for irrigating the lawn of the local football stadium (Figure 1), samples from filter washings were collected in the first and the third minute after the cleaning was started. In the Lab were submitted to differing sedimentation periods (0, 2, and 15 hours). Afterward, samples were analyzed for total suspended solids (TSS), pH, turbidity, and total coliforms, fecal coliforms, and streptococci colonies were enumerated. Further information concerning methodology can be found in [12].

TABLE 1: Swimming pools/filter characteristics and water consumption in filters backwashing process.

Characteristics	Competition Pool	Learning Pool
Pools		
Dimensions (L x W) (m)	25 x 17	16.6 x 10
Base area (m^2)	425.0	166.6
Minimum depth (m)	1.8	0.7
Maximum depth (m)	2.0	1.3
Water volume (m^3)	890.0	160.0
Filters		
Number	2	2
Diameter (mm)	2,000	1,400
Filtration surface (m^2/ft^2)	3.1/33.8	1.5/16.6
Filtration speed ($L/min/m^2$)	500	500
Flow rate (L/min)	1,566.7	766.7
Water consumption: filter backwashing (m^3/year)	2,818.8	1,378.8

3. Results and discussion

The average annual water consumption in building A is around 3,500.5 m^3. The estimated annual water consumption for showers is 1,785.26 m^3 (51% of the total water consumption) (Table 2). Therefore, the greywater generated by showers can be reused in the flushing cisterns, whose predicted consumption is about 840.12 m^3/ year.

The daily consumption for the flushing cisterns is around 2.92 m^3/day, and the daily greywater produced by showers is 6.20 m^3/day (Table 2). Therefore, it is recommended the acquisition of a water recycler dimensioned for the observed water flux to minimize the gap between the inflow of greywater and its consumption. Indeed, raw/untreated

Table 2: Water consumption estimation by use category in building A.

Equipment	Consumption			%
	(m^3/year)	(m^3/month)	(m^3/day)	
Flushing cisterns	840.12	70.01	2.92	24
Urinals	70.01	5.83	0.24	2
Washing basins	735.11	61.26	2.55	21
Showers	1,785.26	148.77	6.20	51
Other uses	70.01	5.83	0.24	2
Total	3,500.50	291.71	12.15	100

greywater shall only be stored temporarily in a tank for less than 24 hours [13] to avoid bad odors and good conditions for pathogens proliferation [14], to reduce turbidity and TSS to admissible values [15-18].

The predicted water consumption reduction can reach 24% (from 3,500.5 to 2,660.4 m^3/year), and the annual water bill cutback would be € 4,594.22 [19].

The average daily water consumption for swimming pool filters backwashing was 15.7 m^3 (competition pool) and 7.7 m^3 (learning pool). Therefore, the estimated annual water consumption for filter washing were 2,818.8 m^3 and 1,378.8 m^3, respectively, totaling 4,197.6 m^3 (Table 1). TSS and turbidity showed higher values in the samples collected during the first minute of the filter backwashing (first flux). In those collected in the third minute, a reduction between 10% and 20% occurred in the studied parameters. Concerning TSS, the two and the fifteen-hour sedimentation reduced the amounts of suspended solids by 60 and 80 %, respectively. Turbidity showed a similar trend. Nevertheless, TSS and turbidity values exceeded the permissible values [15-18], except those submitted to fifteen-hour sedimentation (Table 3). pH values were always in the admissible range. Total coliforms, fecal coliforms, and fecal streptococci were not detected.

[1]Flushing cistern quality requirement: TSS 10 mg/L; Turbidity 2 NUT [15].

[2]Irrigation quality requirement: TSS 10 mg/L; Turbidity 2 NUT [15]. Irrigation of private gardens. For lawn irrigation, the same requirements were adopted.

[3]Recommended limit: Free residual chlorine 0.2 - 0.6 mg/L [16,17]; pH: 6.5-9.0 [16].

The regular swimming pool filters backwashing is unavoidable. Nevertheless, this process generates large amounts of water, usually discharged into the sewage contributing to the water (and energy) use inefficiencies. Therefore, it is crucial to promote the sustainable management of filter washings. The preliminary results showed that this water could not be directly reused because it does not fulfill the regulation requisites. However, the sedimentation process seemed to effectively reduce these parameters

TABLE 3: TSS, turbidity, free chlorine, and pH values observed in 1 and 3 minutes samples submitted to different sedimentation times.

Parameter	Sample sedimentation time	Values (1,2,3)
TSS (mg/L)	No sedimentation (1 min)	61.5
	Sedimentation 2 h (1 min)	24.5
	Sedimentation 15 h (1 min)	9.0
	No sedimentation (3 min)	49.5
	Sedimentation 2h (3 min)	21.5
	Sedimentation 15 h (3 min)	10.0
	No sedimentation (1 min)	36.1
	Sedimentation 2 h (1 min)	5.0
Turbidity (NTU)	Sedimentation 15 h (1 min)	1.7
	No sedimentation (3 min)	25.5
	Sedimentation 2h (3 min)	5.9
	Sedimentation 15 h (3 min)	1.9
Free residual chlorine (mg/L)	No sedimentation (1 min)	0.58 Row 14
	Sedimentation 2 h (1 min)	0.12 Row 15
	Sedimentation 15 h (1 min)	0.02 Row 16
	No sedimentation (3 min)	0.42 Row 17
	Sedimentation 2 h (3 min)	0.11 Row 18
	Sedimentation 15 h (3 min)	0.02
	No sedimentation (1 min)	6.7
	Sedimentation 2 h (1 min)	7.1
pH	Sedimentation 15 h (1 min)	7.8
	No sedimentation (3 min)	6.8
	Sedimentation 2h (3 min)	6.4
	Sedimentation 15 h (3 min)	7.8

to permissible values, allowing the reuse of this water for irrigation or flushing toilets system. Similar results were found by Łaskawiec et al. (2016) [8] and by Wyczarska-Kokot and Lempart (2018) [10]. 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 after installing a relatively simple system for their treatment, such as a settler or a settling tank [8,10]. 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 7,200 m^3 (data provided by Bragança Municipality). Therefore, in the future, filter backwashing could be fully reused for this purpose. Nevertheless, the treated backwashing could also be used in the flushing cisterns or, after a broader treatment, reintroduced back into the swimming pool [20]. However, due to the lack of specific legislation for backwashing monitoring and quality control, other indicators such as nutrients, micropollutants, and other chlorine forms [11, 20] should be determined and monitored before deciding on the best reuse for the water from the filter backwashing.

4. Conclusions

In a scenario of increasing water demand and scarcity, implementing measures leading to greywater reuse when quality drinking water is not required for water supply is paramount. The present study showed that it is possible to promote a substantial increase in water use efficiency in the municipal sports center, promoting water reuse measures, which contribute to the financial burden reduction and increasing environmental benefits. Indeed, sports centers have substantial operational costs due to extensive water consumption, indirectly implying significant energy consumption levels. Herein, the evaluation of the energy consumption under the scope of water-energy nexus was not evaluated. Consequently, the earnings for implementing the suggested measures are monetarily and environmentally much higher than the estimates obtained herein. In short, the current approach indicates that the reuse of greywater and filter backwashing is not only feasible but can lead to a significant reduction of water consumption in the municipal sports center, reducing the environmental impacts associated with urban water demand. Nevertheless, future approaches are needed to fully evaluate the feasibility of water reusing for irrigation and, eventually, for other purposes, in terms of the water–energy nexus, water quality, and investment turnover.

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