Rainwater Use for Non-Potable Purposes: The Case of Riomar Shopping- Recife

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Abstract-- **This research aims to present major elements of rainwater harvesting system (RHS) to supply non-potable consumption points, using as a case study, the system deployed by shopping RioMar- Recife. The initial diagnosis included the building and water demands characterization, as well as a study of sizing methodologies for calculating the reservoir volume. Through the data collected, it was possible to analyze the potential of the existing reservoir depending on the conditions of local precipitation and of the catchment area adopted. Through the results obtained by the simulation method, comparing different values of fixed monthly demands, it could be verified that the deployed system has the capacity to serve a fixed monthly water demand of 1.439 m³, representing a 100 % autonomy. The analysis also compared the autonomy of a fictitious reservoir, bigger than the volume executed, in order to check if this could offer less water losses in the same period of 2013.The amount of rain water captured contributes substantially to a more efficient management of this resource throughout its use cycle.**

Index Term-- **Rainwater harvesting systems, rainwater re-use, reservoirs sizing.**

INTRODUCTION

According to Coelho (1999), the population increase and the consequent increase of urban consumption grew faster than the capacity to discover new water supply sources and distribution systems. Furthermore the scarcity of new water supplies has sparked a common interest in the global scientific community to seek technological solutions to reduce waste and encourage the rational use of water. According to ANA (2005) data, Pernambuco is historically noted as the state with lower water availability in Brazil. This finding should be treated by the present authorities as a threat to the State economic growth continuity (ANA, 2005).

The adoption of measures aiming to reduce consumption and search for alternative water sources is becoming an increasingly necessary practice from the water availability and environmental sustainability point of view. The rainwater harvesting is presented, in this context, as a social and environmental alternative economically possible, in order to meet less stringent demands, characterized by non-potable uses, provided they met the relevant requirements. Unconventional systems for rainwater reuse are already used on a large scale in developed countries.

METHODOLOGY

This present work was developed primarily in three distinct stages. The first was characterized by literature research, study of Recife rainfall indexes, calculation methodologies and examples of existing rainwater use systems. The second stage was designed to field research, including visits to the building, consultations with the shopping technical staff and photographic records of existing RHS installations. Finally, in possession of the collected data, it was possible to evaluate the ability to supply non-potable water by the shopping RHS.

For the analysis of the demand that the Riomar shopping RHS can meet it was adopted the simulation method simulation, materialized in spreadsheets, which proved to be more adequate because the reservoir volume was already set, as well as the catchment area and the collectors, since the system was already built.

A comparison between different numerical values of monthly demands was prepared, setting the volume of the existing reservoir and catchment area adopted, in order to also evaluate the reliability that it could provide the shopping. It was also verified the dynamics of a fictitious reservoir (with a higher volume than the existing one). Both comparisons were performed using spreadsheets developed in Microsoft Excel 2010.

Spreadsheets developed for this work summarize the simulation method calculations, based on the data from the existing RHS. The spreadsheets input data are: average monthly rainfall; constant demand; catchment area; volume of the reservoir; runoff coefficient (considers the mitigation of contribution amounts due to evaporative losses, leaks, initial disposal, in calculations; the value used was 0.8). As output data will be presented: total annual rainfall; rainwater volume; previous tank level; post reservoir level; spills (volume of water that exceeds the reservoir limit capacity after water entry and demand withdrawal); supply; system autonomy; attended annual demand; replacement volume; wasted volume.

Case study

The Riomar mall is located on Republic of Lebanon Avenue, nº 251, in Pina district, in a privileged location in the south of the Recife Metropolitan Region, close to the financial, legal and medical centers in the region. It opened on October 30, 2012, and occupies a building area of approximately 295.000m2, on 201.710m2 plot, and is divided into more than 380 satellite shops, 17 anchor stores, eight megastores, food court with 12 restaurants area beyond the 12-screen cinema, theater, bowling, and many other attractions. Figure 1 shows Shopping Riomar aerial view.

Fig. 1. Shopping Riomar Aerial View. Source: Souza (2013).

The Shoping still has an implanted 40,000 m2 green area and 6,200 parking spaces. Its projection in plant occupies an area of approximately 70,000 m2, with approximately 50,000m2 of roof and waterproof flagstone that could be used to capture rainwater.

The water supply is through a Pernambuco Sanitation Company (COMPESA) branch line connected to the lower reservoir (capacity 1,300 m³) with the potential to meet two mall consumption days on average. A pumpimg system promotes pressurization of the internal water extensions, so consumers are satisfied with flow and pressure adequate to their needs.

The Rainwater Utilization System deployed in Riomar Recife is composed by the following subsystems:

a) Capture and ductwork: Captured rainwater comes from part of the roof and uncovered parking areas (highest floor). The collection is made through the roof gutters installed in the rooftops eaves. The water collected is conducted through specific pipes to the pre-filters that precede the water entry into the reservoir.

b) Pre-filters (early discharge): Work by forming an inner vortex that separates the water from impurities (leaves, twigs, insects, etc). With this use filters assume the function of first water disposal, as recommended by NBR-15527 (ABNT, 2007).

c) Water treatment (sand filters and oil separation): After passing the pre-filters the water is led to two sand filters systems, one that receives the contribution from the rooftops and another that receives parking water, the later having a water and oil separation system to prevent the entry of these residues in the storage tank.

d) Reservoir: After passing the filter water is directed into the collection reservoir, which can hold 3,566 cubic meters of non-potable water and occupies a floor area of approximately 240 m².

e) Distribution network: The reservoir pipes exit toward two independent pumping systems, one to feed the consumption points of the mall and another to serve the garden irrigation system. Figures 2, 3, 4 and 5 show parts of the RHS subsystems described above:

Fig. 2. Rooftop stretch. Source: Souza (2013).

Fig. 3. RHS pipes network. Source: Souza (2013).

Fig. 4. Pre-filters. Source: Souza (2013).

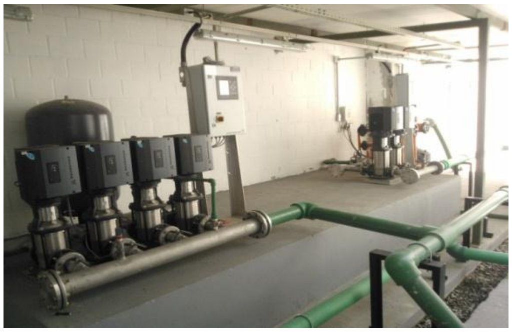

Fig. 5. Distribution network. Source: Souza (2013).

The rainwater harvesting system provides lavatories and urinals in public toilets, as well as the irrigation system through specific piping and pumps, totally separated from the mall drinking water system. All Anchor stores receive hydraulic supply from an extension of the rainwater system. Monitoring of all water demands of the different non-potable consumption points is not being done yet, due to the fact that specific water meters have not been installed in each section of the system.

RESULTS AND DISCUSSION

Based on the catchment area and the reservoir volume, it was possible to develop a comparative analysis of the potential contribution of the RHS deployed in relation to the shopping demands that can be met by non-potable water. Through the simulation method, by fixing the catchment area, other demands were simulated by iterative process, in order to check the autonomy of the system implemented as a function of the rainfall regime considered.

The calculation hypothesis simulated variable demands that could meet the irrigation and public toilets (lavatories and urinals) needs, with a catchment area of 26,000 m^2 (7,000 m^2 in the rooftop and 19,000 m^2 in the parking lot), a runoff coefficient C = 0.80, using the monthly average rainfall of 2004 (the year 2004 was chosen because its total rainfall was closer to the 2303 mm annual average observed in the last 50 years (SOUSA, ASSIS, *et al.*, 2013).

Below is presented the options set simulated:

a) Option 01 – Demand: 1.439 m^3/month, existing reservoir with 3.566 m^3;
b) Option 02 – Demand: 2.000 m^3/month, existing reservoir with 3.566 m^3;
c) Option 03 – Demand: 3.000 m^3/month, existing reservoir with 3.566 m^3;
d) Option 04 – Demand: 3.566 m^3/month, existing reservoir with 3.566 m^3;
e) Option 05 – Demand: 1.439 m^3/month, fictional reservoir with 5.000 m^3;
f) Option 06 – Demand: 2.000 m^3/month, fictional reservoir with 5.000 m^3;
g) Option 07 – Demand: 3.000 m^3/month, fictional reservoir with 5.000 m^3;
h) Option 08 – Demand: 3.566 m^3/month, fictional reservoir with 5.000 m^3;

Through the obtained results analysis it was verified that:

In **Option 1**, by iterating the demand values, the maximum that the existing reservoir will be able to attend is 1,439 m^3/month (17,268 m^3/year) with a 100% autonomy (no replacement with another water source). However, it will represent a total annual overflow volume wasted of approximately 32,884 m^3. Figure 6 shows the results for option 1.

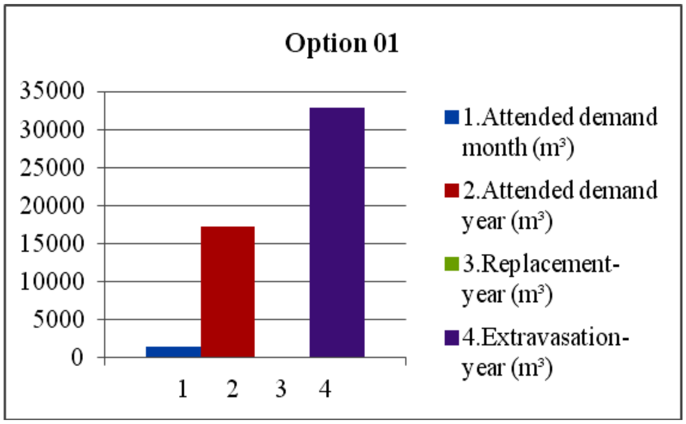

Fig. 6. RHS water balance graphic - Option 01. Source: Souza (2013)

In **Option 2**, arbitrating a maximum monthly demand of 2,000 m3 (21,756 m3/year), the existing reservoir will meet the needs with a 83% autonomy, requiring replacement by another water source in November and December (2,244 m3/year). However, it will represent a total annual overflow volume wasted of approximately 28,400 m^3. Figure 7 shows the results for option 2.

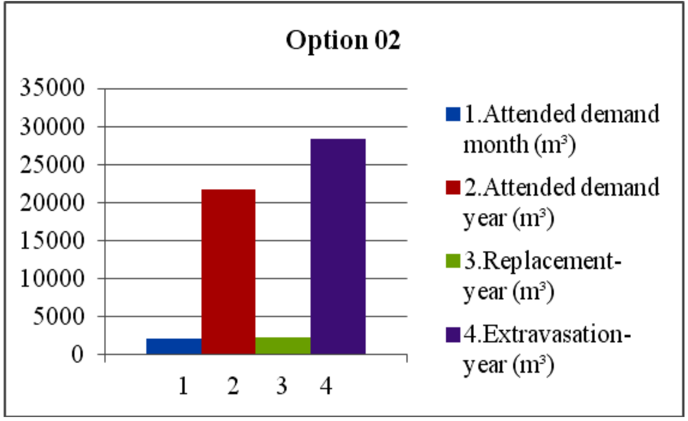

Fig. 7. RHS water balance graphic - Option 02. Source: Souza (2013).

In **Option 3**, arbitrating a maximum monthly demand of 3,000 m3 (29,286 m3/year), the existing reservoir will meet with a 75% autonomy, requiring replacement by another water source in November and December (6,714 m3/year). However, it will result in a total annual overflow volume wasted of approximately 20, 866 m3. Figure 8 shows the results for option 3.

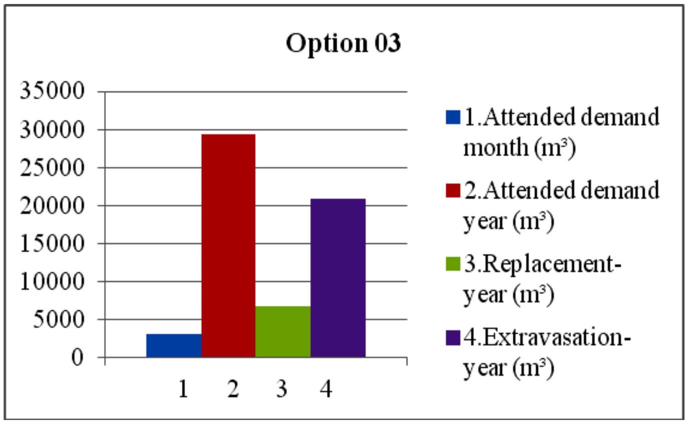

Fig. 8. RHS water balance graphic - Option 03. Source: Souza (2013)

In **Option 4**, arbitrating a maximum monthly demand of 3,566 m3 (32 248 m3/year), the existing reservoir will meet with a 75% autonomy, requiring replacement by another water source in November and December (9,544 m3/year). However, it will result in a total annual overflow volume wasted of approximately 16,904 m3. Figure 9 shows the results for option 4.

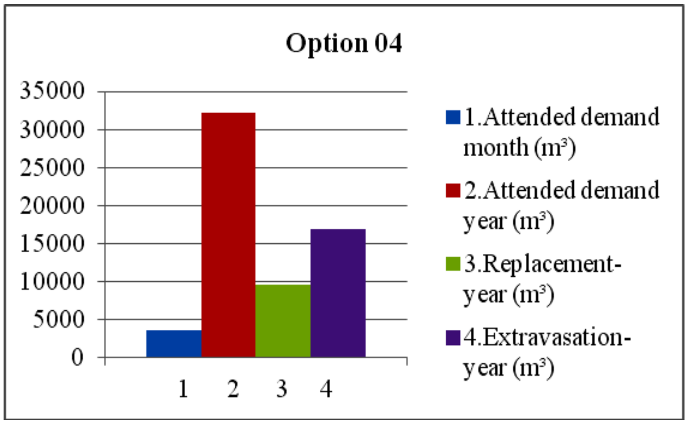

Fig. 9. RHS water balance graphic - Option 04. Source: Souza (2013).

In **Option 5**, considering a fictitious reservoir of 5,000 m3, making the iteration of demand values, the maximum that it will be able to meet is 1,797 m3/month (21,564 m3 per year) with a 100% autonomy (no replacement by another water source). However, it represents a total annual overflow volume wasted of approximately 30,019 m3.

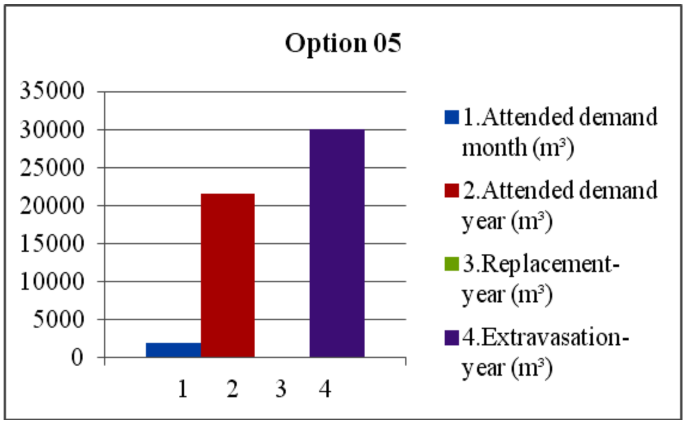

Fig. 10. RHS water balance graphic - Option 05. Source: Souza (2013).

In **Option 6**, considering a fictitious reservoir of 5,000 m3 and arbitrating the iteration of the maximum monthly demand of 2,000 m3 (23,190 m3/year), the reservoir will be able to meet the needs with a 92% autonomy requiring replacement by another water source in December (810 m3/year). However, it represents a total annual overflow volume wasted of approximately 28,396 m3. Figure 11 shows the results for option 6.

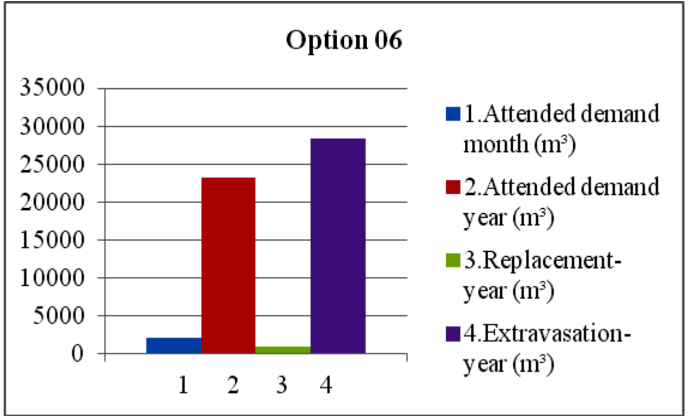

Fig. 11. RHS water balance graphic - Option 06. Source: Souza (2013).

In **Option 7**, considering a fictitious reservoir of 5,000 m3 and arbitrating the iteration of the maximum monthly demand of 3,000 m3 (30,720 m3/year), the reservoir will be able to meet the needs with a 83% autonomy requiring replacement by another water source in November and December (5,280 m3/year). However, it represents a total annual overflow volume wasted of approximately 20,866 m3. Figure12 shows the results for option 7.

In **Option 8**, considering a fictitious reservoir of 5,000 m3 and arbitrating the iteration of the maximum monthly demand of 3,566 m3 (34,682 m3/year), the reservoir will be able to meet the needs with a 75% autonomy requiring replacement by another water source in December (8,110 m3/year). However, it represents a total annual overflow volume wasted of approximately 16,904 m3. Figure 13 shows the results for option 8.

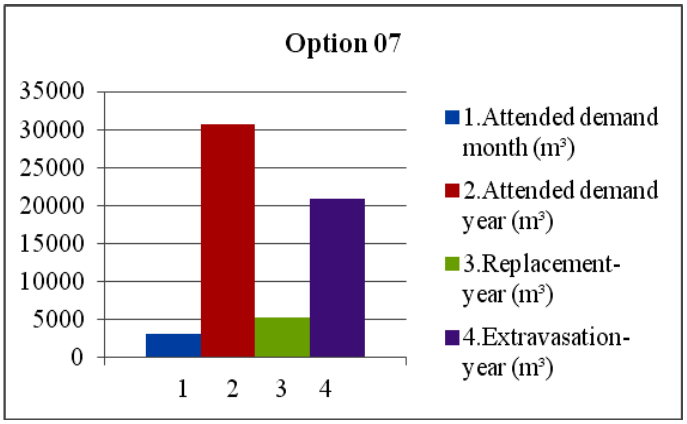

Fig. 12. RHS water balance graphic - Option 07. Source: Souza (2013).

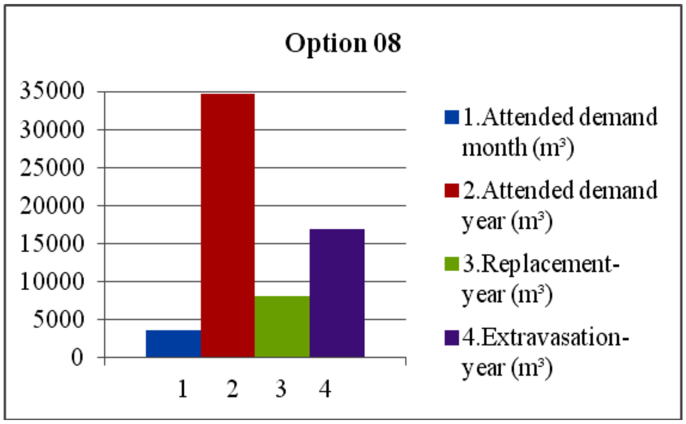

Fig. 13. RHS water balance graphic - Option 08. Source: Souza (2013).

The calculations presented are mathematical models and represent an effort to simulate ideal situations, but reality is uncertain and changes can occur since rain regimes are influenced by a series of natural factors that can cause changes favorable or not, and therefore positively or negatively influence the RHS efficiency.

The RHS efficiency also depends, beyond the natural conditions of rain supply, of the reservoirs levels monitoring in line with the local rainfall regime, so that its volume capacity to receive collected water may be always preserved, minimizing the replacement with other water sources.

CONCLUSIONS

This study met its target bringing more information on the topic of rainwater harvesting, presenting a practical example showing the system deployed by Riomar Shopping in Recife. It identified the RHS main elements and its potential use for the non-potable water consumption units in the building. It was demonstrated that the existing RHS has the capacity to meet a fixed monthly demand of 1,439 cubic meters of water with 100% autonomy.

This example shows the importance of this kind of technological solutions in bringing sustainable construction into practice with significant sustainability achievements to the society.

REFERENCES

[1] ABNT. NBR-15527 Água de Chuva - Aproveitamento de coberturas em áreas urbanas para fins não potáveis - Requisitos. Rio de Janeiro: ABNT, 2007.

[2] ANA. Programa da qualidade das águas superficiais do Brasil. [S.l.]: [s.n.], 2005. Available in: http://arquivos.ana.gov.br/planejamento/estudos/sprtew/2/2-ANA.swf .

[3] COELHO, A.C.; MAYNARD, J.C.B. Medição Individualizada de Água em Apartamentos. Recife, Pernambuco, Ed. Comunicarte, 1999. 172p.

[4] RIOMAR. Acompanhamento das utilidades do shopping. Shopping Riomar. Recife. 2013. Fornecido pelo gerente da manutenção do shopping (Água, Gás, Energia elétrica).

[5] SOUSA, W. S. et al. Análise do comportamento das chuvas durante os últimos 50 anos (1961 - 2011), na cidade do Recife/PE. Revista Pernambucana de Tecnologia, Recife, v. 1, n. 1, p. 6-14, Outubro 2013.

[6] SOUZA, José Alberto Lopes de. **Aproveitamento de Águas Pluviais para Fins Não potáveis: O caso do RioMar Shopping Recife.** 2013. 92 f. TCC (Graduação em Engenharia Civil)- Escola Politécnica, Universidade de Pernambuco, Recife, 2013.