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Simulation of the use of rainwater in two schools in the public municipal education network in Aracaju-SE

Simulación del uso del agua de lluvia en dos escuelas de la red municipal de enseñanza en Aracaju-SE

Leandro de Assis Ferreira[1] , Zacarias Caetano Vieira[2] , Ana Paula Cardoso Melo Barreto[3] , Maria Heloisa Santos de Souza[4] & Sarah Rolemberg da Silva Ramos[5]

Abstract: With an increasing frequency periods of intense water scarcity are recorded in various parts of the planet. A measure that can be very efficient, is using rainwater, preserving potable water for use where it is needed, and contributing to the fight against urban floods. Considering the foregoing, this article aims to capture's simulation and use of rainwater in two schools of the public municipal education network of Aracaju-SE, through the estimation of non-potable demand, estimation of the catchable volume, verification of the attendance of the estimated non-potable use and the impact of this action on the urban drainage system. Based on the roof area and the average's data of precipitation, the volume of water captured by the roof was calculated, and finally, a demand for non-potable use was estimated, verifying if this demand is attended, in addition, the impact generated on the local urban drainage system was analyzed. The results indicate that: a) The Oviedo Teixeira School had an average demand of 258 m³, an average catchable volume of 326 m³ and an average reduction of 66% in the volume thrown into the drainage; b) The Anísio Teixeira School had an average demand of 60 m³, an average catchable volume of 140 m³, and an average reduction of 53% in the volume thrown into drainage. It is concluded that rainwater totally meets the estimated demand and rainwater harvesting positively impact on the drainage system, if used on a large scale.
Keywords: *Non-potable uses; Cistern; Urban drainage.*

Resumen: Cada vez con mayor frecuencia, se registran períodos de intensa escasez de agua en diversas partes del planeta. Una medida que puede resultar muy eficiente es el aprovechamiento del agua de lluvia, preservando el agua potable para su uso donde realmente se necesita y contribuyendo a la lucha contra las inundaciones urbanas. En vista de lo anterior, este artículo tiene como objetivo simular la captación y uso del agua de lluvia en dos escuelas de la red municipal de educación de Aracaju-SE a través de la estimación de una demanda no potable, estimación del volumen captable, verificación de la concurrencia del uso no potable estimado y el impacto de esta acción en la red de drenaje urbano. A partir de la superficie de la cubierta y de los datos de precipitación media, se calculó el volumen de agua captada por la cubierta y, finalmente, se estimó una demanda de uso no potable, verificando si esta demanda es atendida y, por último, se analizó el impacto generado sobre la red de drenaje urbano local. Los resultados muestran que: a) la Escuela Oviedo Teixeira tuvo una demanda media de 258 m³, un volumen medio captable de 326 m³ y una reducción media del 66% del volumen arrojado al drenaje; b) la Escuela Anísio Teixeira tuvo una demanda media de 60 m³, un volumen medio captable de 140 m³ y una reducción media del 53% del volumen arrojado al drenaje. Se concluye que las aguas pluviales satisfacen

*Author for correspondence
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[1] Student, Federal Institute of Sergipe, englafcivil@gmail.com; ORCID: https://orcid.org/0000-0002-1660-4656;*
[2] Professor, Federal Institute of Sergipe, zacariascaetani@yahoo.com.br; ORCID: https://orcid.org/0000-0001-5019-0971;
[3] Student, Federal Institute of Sergipe, anap_melo95@hotmail.com; ORCID: https://orcid.org/0009-0006-5684-1070;
[4] Student, Federal Institute of Sergipe, heloisasantoseng@gmail.com; ORCID: https://orcid.org/0009-0007-3895-3244;
[5] Student, Federal Institute of Sergipe, sarahrolembergsr@hotmail.com; ORCID: https://orcid.org/0000-0001-8104-650X.

plenamente la demanda estimada y la recogida de aguas pluviales puede tener un impacto positivo en la red de drenaje, si se utiliza a gran escala.generados.
Palabras clave: *Usos no potables; Depósitos; Drenaje urbano.*

INTRODUCTION

The growing development of societies and the corresponding increase in population have led to situations in various parts of the planet where water resources are scarce in both quantitative and qualitative terms (SILVA; LUCENA, 2015). Adding to this information, Sharma and Vairavamoorthy (2009) emphasize that the limitation of available water resources increases competition between the water uses and, in addition, reduces access to good quality water, making urban supply a major challenge for water resource management.

According to the manual Conservation and Reuse of Water in Buildings (ANA/FIESP/Sinduscon/SP, 2005 *apud* PETERS, 2006), alternative water sources are all those that are not under concession from the public services or that are not charged for their use. According to Peters (2006), in Brazil these sources are those which are not included in the national water resources management system, such as: soil water, groundwater, rainwater and the reuse of treated effluents.

One measure that can be very efficient is the exploitation of rainfall water, since, in addition to making it possible to replace sources, preserving potable water for use where it is really needed, also helps to combat urban flooding (NOVAKOSKI; MARQUES; CONTERATO, 2013). The use of rainwater saves potable water for less noble uses, such as washing vehicles, reserving water for firefighting, washing clothes, and refilling toilets (MAY, 2004).

In view of the above, this article's main objective is to realize a simulation of the capture and use of rainwater in two schools in the public municipal education network in the city of Aracaju, capital of the state of Sergipe. To this aim, the following were carried out: estimation of a non-potable demand, estimate of the catchable volume, verification of compliance with estimated non-potable use, and the impact of this action on the urban drainage network.

THEORETICAL BACKGROUND

According to Vieira and Fernandes (2015), rainwater collection and use systems are basically made up of the following parts:

> "Catchment area (usually the roof of the building), which can be made of ceramic tiles, metal tiles, etc.; gutters and conductors; grids and filters; disposal or self-cleaning system. From the catchment area, the water is directed to the gutters and vertical conductors which are responsible for taking the water to disposal device of the

> first rainfall, when it exists, or directly to the storage reservoir, being the most used materials, polyvinyl chloride (PVC) or plastic. The grids and filters have the function of preventing coarse materials such as leaves, twigs and small animals that remain on roofs from reaching the catchment system; the disposal device has the function of temporarily retaining and then discard the first millimeters of rain because it is of inferior quality; and finally the cisterns or reservoirs accumulation that stores the water that will be used in the building, which can be made of various materials (concrete, masonry, PVC, fiberglass, etc.), installed in various ways (buried, semi-buried, supported on the ground or elevated), built (reservoirs molded *in loco*) or bought ready-made (industrialized reservoirs)."

Among the advantages of catching and using rainwater we can mention: the reduction in the demand for water supplied by sanitation companies, resulting in a reduction of potable water costs and a reduction in the risk of flooding in cases of heavy rainfall; investment are minimal to adopt rainwater catching on the vast majority of roofs; and the system can be installed in any environment: whether rural or urban, house or apartment (MAY, 2004; MALTA, 2013; ECYCLE, 2013 *apud* LIMA, 2015).

METHODOLOGY

Study area

To carry out this work, the Oviedo Teixeira Municipal School and the Anísio Teixeira Municipal School, part of the public municipal education network in Aracaju-SE, were considered objects of study.

Estimated non-potable use

Water consumption for non-potable uses in the schools studied will be estimated based on Fasola *et al.* (2011) who indicated that 72% of total consumption is for so-called non-potable uses.

Coverage Area

The coverage areas were provided by the Municipal Department of Education (SEMED) of Aracaju. The Oviedo Teixeira School has a total coverage area of 3,062.43 m² (Figure 01) while the Anísio Teixeira School has a coverage area of 1,314.19 m² (Figure 01).

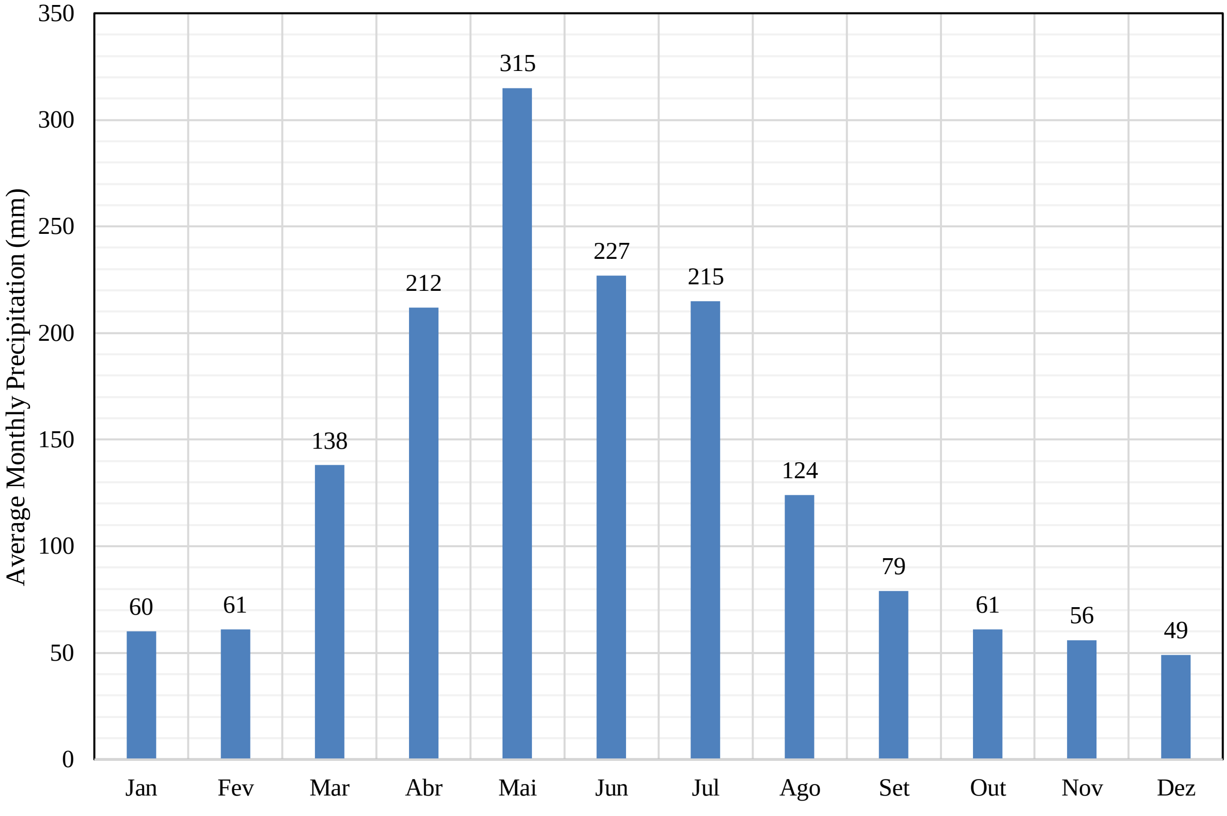
FIGURE 01: Roof of the schools Oviêdo Teixera (left) and Anísio Teixera (right).

SOURCE: google.com/googleearth (2023).

Rainfall data

To carry out the simulation, the average monthly rainfall for the city of Aracaju-SE will be adopted, as shown below, in Graph 1:

GRAPH 01: Average monthly rainfall (mm) in Aracaju-SE.



SOURCE: https://sedurbi.se.gov.br/portalrecursoshidricos (2023).

Volume of catchable monthly rainfall

To determine the volume of rainfall captured by the school roof, the constant equation in Tomaz (2003) was used:

$$Q = A \times C \times P \quad [1]$$

Where: A is the collection area, in square meters (areas in Figure 1); C is the superficial runoff coefficient, adopted as 0.80 (ceramic tiles); P is the average monthly rainfall, in millimeters, shown in Graph 1; Q is the monthly volume produced by the rain (catchment volume), in liters.

Analysis of the impact of using a rainwater reservoir on the drainage network

Regarding rainwater utilization reservoirs, Teston (2015) reports that their use for non-potable purposes in buildings can contribute to reduce flooding. To simulate the impact of using rainwater, the percentage of reduction in the volume of water discharged into the drainage network will be calculated for each month, according to Equation 2, below:

$$\text{Reduction (\%)} = (V_{SC} - V_{CC}) / V_{CC} \quad [2]$$

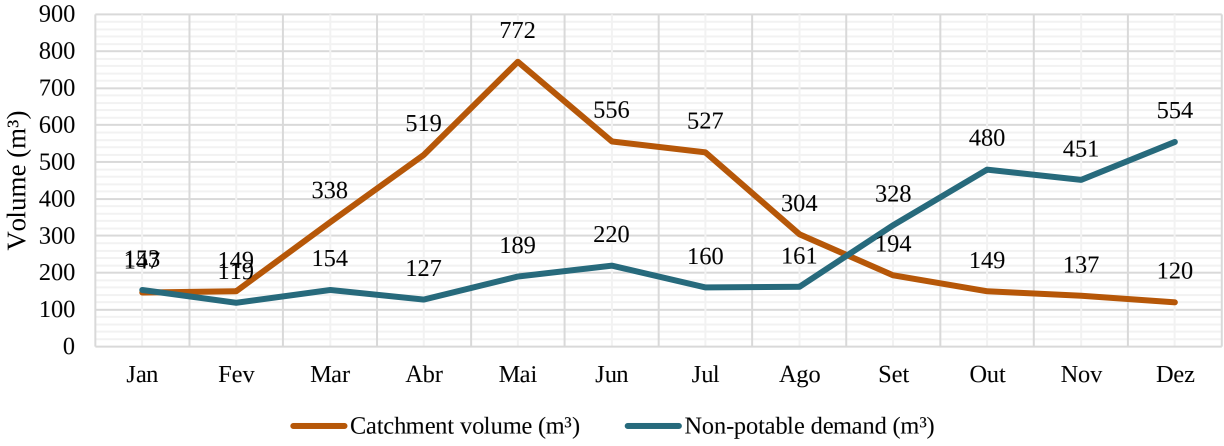
Where: V_{CC} = is the volume discharged into the drainage network with collection and use of rainwater (m³); V_{SC} = is the volume discharged into the drainage network without collection and use of rainwater (m³).

RESULTS AND DISCUSSION

Average monthly demand for non-potable use versus catchment volume

The average demand for non-potable use, that is, the demand that can be met using rainwater, was estimated based on the monthly water consumption of schools in 2022, provided by the Municipal Department of Education (SEMED), and considering 72% of this value, as indicated by Fasola *et al.* (2011). These values will be compared with the average monthly volume catchable by the coverage, considering the use of Equation 1, in addition to the coverage areas and the average monthly rainfall (Graph 1). The results obtained are presented in Graphs 2 and 3 below.

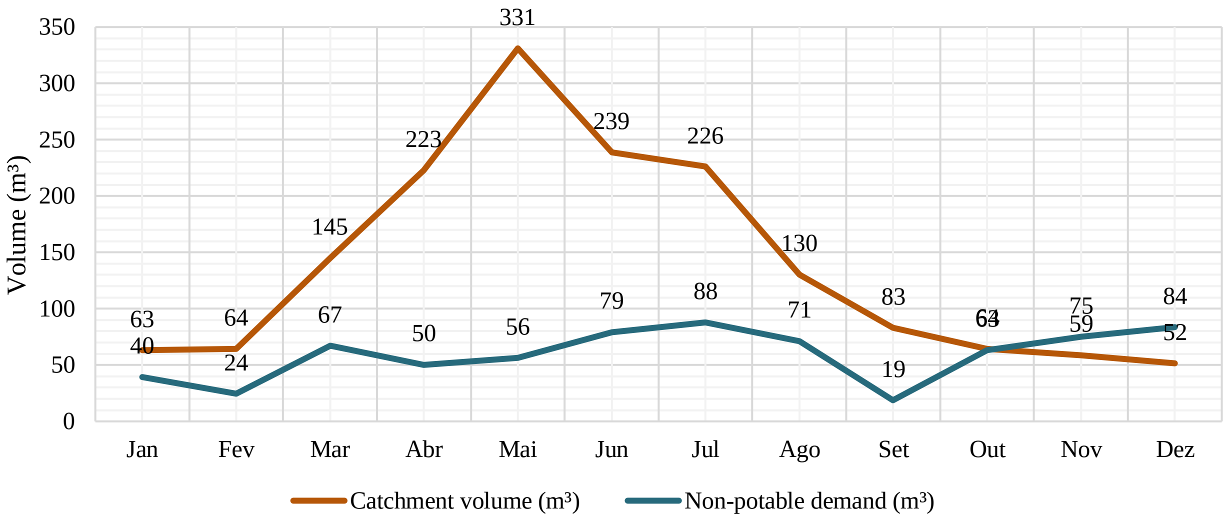
GRAPH 02: Non-potable use demand versus catchment volume at Oviedo Teixeira School.



SOURCE: The authors (2023).

At the Oviedo Teixeira School, the non-potable use demand varied from 118.8 m³ (February) to 554.4 m³ (December), resulting in a monthly average of 258 m³. Concerning to the volume of rainfall catchable by the coverage, it varied from 120 m³ (December) to 772 m³ (May), resulting in an average of 326 m³, that means, approximately 26% higher than the non-potable use demand.

GRAPH 03: Non-potable use demand versus catchment volume at Anísio Teixeira School.



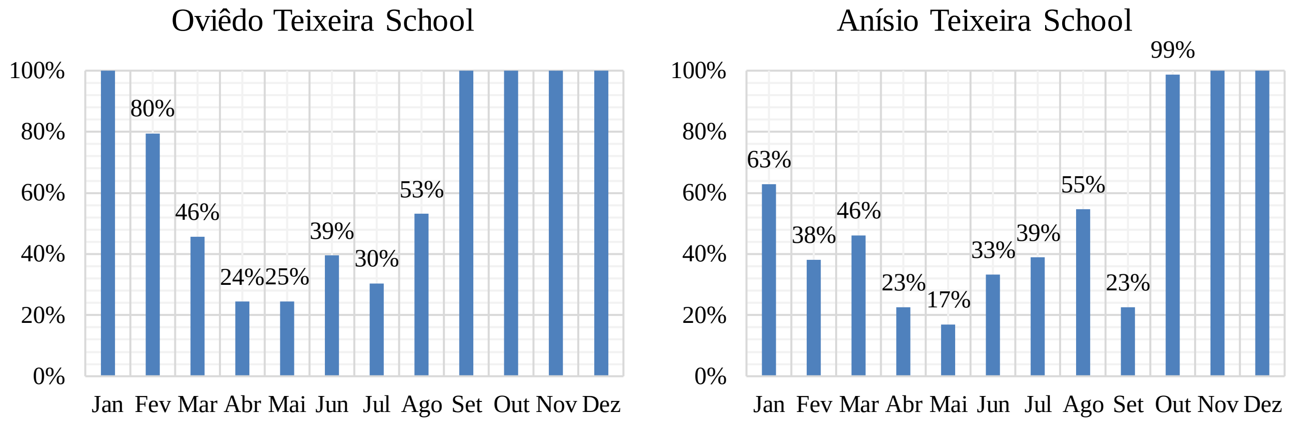
SOURCE: The authors (2023).

At the Anísio Teixeira School, the non-potable use demand varied from 19 m³ (September) to 88 m³ (July), resulting in a monthly average of 60 m³. Regarding the volume of rainfall catchable by the coverage, it varied from 52 m³ (December) to 331 m³ (May), resulting in an average of 140 m³, that means, approximately 169% more than the non-potable use demand.

Analysis of the impact of using the rainwater reservoir on urban drainage

To analyze the impact of collecting and using rainwater, the reduction in the volume of water discharged into the urban drainage system will be calculated for each month using Equation 2. The results are shown in Graph 4 below.

GRAPH 04: Reduction in the volume discharged into the urban drainage system with the collection and use of rainwater.



SOURCE: The authors (2023).

At the Oviedo Teixeira School, the reduction in the volume discharged into the drainage network varied from 24% to 100%, resulting in an average of 66%; while at the Anísio Teixeira School, this reduction varied from 17% to 100%, resulting in an average of 53%. So, in the months with the highest rainfall, the volume of water caught by the coverage is much greater than the estimated demand, filling the reservoir more quickly, and consequently, the volume overflowing into the drainage system is much greater, resulting in lower percentage reductions. In periods with low rainfall, the opposite occurs, the reservoirs fill more slowly, the volume overflowed is lower - in some months it was zero - and consequently the percentage reduction is high.

CONCLUSIONS

a) The rainwater captured by the coverage fully meets the estimated demand for non-potable uses in the two schools, which is justified by the high rainfall in the city of Aracaju-SE and the large catchment area of these schools;
b) The use of rainwater tanks in buildings can make a significant contribution to reducing the volume of water discharged into the drainage system;

c) Even in months of high rainfall, the use of rainwater reservoirs has a positive effect, as it delays the time at which this volume of water is discharged into the drainage system, reducing the peak flow, and increasing the time of occurrence of this flow.
d) For the use of rainwater tanks to have a significant impact on the urban drainage system, they need to be used on a large scale.

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