

# Water Reuse Production Station (EPAR): Assessment of Eco-efficiency in Blackwater Reuse — A Case Study in Porto Alegre, Brazil

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**Abstract:** Blackwater reuse is a growing practice, integrating technological solutions for water sustainability and natural resource management. This master's research proposes to evaluate the Water Reuse Production Station (EPAR) installed in an administrative building in Porto Alegre, RS, Brazil, a development that holds LEED Platinum certification for sustainable buildings. The aim is to analyze its potential as a model of environmental and economic efficiency in sustainable urban constructions. Based on the future collection and analysis of operational monitoring data and water quality parameters, the expected results will indicate the feasibility of EPAR in reducing potable water consumption, verifying its compliance with the regulatory criteria of CONSEMA-RS Resolution No. 419/2020. The economic analysis intends to demonstrate potential reductions in operational costs and the mitigation of environmental impacts, reinforcing the replicable potential of this technology in different urban contexts. This master's work will aim to contribute to advancing knowledge on the eco-efficiency of blackwater reuse and to support future public policies for incentive.

**Key words:** eco-efficiency, EPAR, water reuse

## 1. Introduction

The growing demand for potable water in urban areas and the impacts of climate change highlight the need for technologies that optimize water resource usage. Water Reuse Production Stations (EPARs) emerge as innovative solutions to treat blackwater, transforming it into resources for non-potable uses such as irrigation, cleaning, and toilet flushing. This study investigated the eco-efficiency and the associated environmental and economic impacts of the EPAR located in an administrative building in Porto Alegre, Brazil, a project certified with the LEED sustainability seal.

The station, already operational, processes blackwater generated by a 12-story administrative

building serving an estimated average population of 2,000 people, converting it to reusable water for non-potable purposes such as irrigation, toilet flushing, and outdoor cleaning. CONSEMA-RS Resolution No. 419/2020 establishes clear criteria for the reuse of urban, industrial, agricultural, and forestry waters in the state of Rio Grande do Sul, serving as a regulatory reference for the evaluation of treated water quality and practical applications. Furthermore, the LEED certification reinforces the role of EPARs in integrating technological solutions with environmental and economic efficiency.

Several studies emphasize the importance of water reuse as a strategy to reduce pressure on water sources and mitigate the effects of climate change. An economic impact study by the National Confederation of Industry [1] identifies the direct and indirect benefits of investing in reuse technologies, including reduced operational costs and improved water use efficiency in

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industrial and urban sectors. However, there remain gaps in understanding the efficiency of systems like the EPAR in specific contexts, such as large administrative buildings. This project aimed to fill these gaps by investigating the eco-efficiency of this implemented system.

Finally, the study reinforced the potential of EPARs as strategic instruments for water sustainability by connecting innovative technical solutions with urgent demands for environmental preservation and water use efficiency. Alongside contributing to the enhancement of public reuse policies, the results obtained may support initiatives such as the creation of targeted credit lines within funding banks for reuse technologies, fostering cross-sectoral integration of eco-efficiency and sustainable development.

### *1.1 Justification*

The replicability potential of Water Reuse Production Stations (EPARs) was a main focus of this study. Implementation in administrative buildings, with potential expansion to educational institutions such as large schools, demonstrated the versatility and applicability of this technology. However, to ensure effective replication, it was essential to validate the parameters of treated water quality and the reuse volumes achieved, as well as to establish technical and economic guidelines to ensure its feasibility. This analysis can serve as a foundation to promote public policies and financial incentive programs for the implementation of EPARs in various sectors.

Moreover, the environmental benefits associated with blackwater reuse were undeniable. Reducing pressure on water sources, decreasing the generation of effluents discharged into the environment, and lessening the need to extract potable water stand among the direct advantages of adopting this technology. Additionally, initiatives such as EPARs promote broader environmental awareness, encouraging

companies and institutions to adopt sustainable practices that go beyond mere compliance with legislation, contributing to long-term preservation of natural resources. The connection between technological innovation, operational efficiency, and an educational introduction of the topic to schools underscores the practical and academic relevance of this research.

## **2. Material and Methods**

### *2.1 Methods*

The methodology adopted in this study evaluated the efficiency of the EPAR from three main perspectives: treated water quality parameters, the volume of reuse achieved, and the economic and environmental impacts generated. Simultaneously, normative aspects were considered, such as the requirements of CONSEMA-RS Resolution No. 419/2020 and CONAMA Resolution No. 503/2021, as well as economic studies by the CNI, which corroborated the viability and importance of blackwater reuse in different contexts.

The general objective of this study was to evaluate the eco-efficiency of the EPAR in repurposing blackwater for non-potable applications in sustainable buildings. Among the specific objectives were:

- 1) Analyze treated water quality parameters in the case study's EPAR, comparing them to legal standards and ensuring compliance with the criteria defined by CONSEMA-RS Resolution No. 419/2020, guaranteeing safety and feasibility for non-potable uses.
- 2) Identify practical applications of the reuse water and quantify reductions in potable water consumption. This involved evaluating how the reused water was employed (e.g., toilet flushing, irrigation, cleaning) and its effectiveness in reducing dependence on potable water sources.

- 3) Estimate the economic and environmental benefits generated by the EPAR, quantifying financial savings and assessing positive environmental impacts, such as reduced effluents released and lower pressure on water sources.
- 4) Propose strategies for the replication and expansion of the EPAR model, utilizing the study's results to develop guidelines enabling efficient and economically viable implementation of EPARs in other projects.

### **3. Results and Discussion**

#### *3.1 Results*

The results demonstrated that the EPAR achieved significant efficiency in removing microbial and chemical contaminants, ensuring the quality of reused water for non-potable applications. Comparisons with prior studies, such as Bastos et al. (2008) [2], revealed that the system's efficiency aligns with best practices in the field.

Economic analysis highlighted potable water consumption reductions of up to 40%, an achievement consistent with studies by Seckler (2021) [3]. These findings underscored the economic and environmental viability of EPARs, particularly for densely populated urban environments like administrative buildings and schools.

From a regulatory standpoint, the EPAR in this study met all the criteria outlined in CONSEMA-RS Resolution No. 419/2020, ensuring its compliance with state reuse standards. Moreover, the system directly contributed to water sustainability and supported environmental certification processes, with the building already holding a LEED Platinum certification. These findings supported prior research by Cooley (2014) [4], which identified EPARs as indispensable tools for aligning urban development with environmental sustainability.



**Fig. 1** EPAR from case study in Porto Alegre/RS, object of research.

#### *3.2 Discussions*

Normative compliance of the studied EPAR was verified against CONSEMA-RS Resolution No. 419/2020, reinforcing its alignment with the objectives of urban sustainability. The potential contribution of the system to obtaining environmental certifications, such as LEED, was also confirmed, illustrating its role in advancing sustainable water management initiatives in Porto Alegre and Brazil. The study also highlighted the broader implications of integrating EPARs into urban water management strategies, fostering discussions on public financing and technical support for systemic adoption across various sectors.

### **4. Conclusions**

The EPAR analyzed in this case study demonstrated itself to be an efficient and replicable technology for sustainable buildings, significantly reducing pressure on water sources, lowering operational costs, and ensuring compliance with regulatory requirements. The results suggested that EPARs should be recommended for diverse applications, including public and private projects such as schools, condominiums, and administrative buildings.

The findings supported the system's ability to supply a significant portion of non-potable water demands, directly reducing the need for conventional water sources. Additionally, the treated water met the quality

standards required for urban applications, highlighting its safety and practicality.

The economic assessment confirmed the cost-effectiveness of EPAR implementation on a larger scale, demonstrating that the economic and environmental benefits outweigh initial installation and operating costs. These results provide a foundation for creating credit lines and financial incentives for reuse technologies, advancing discussions on water security and sustainable resource management.

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