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# Overview of ICA in Brazilian WWTPs

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**Abstract:** This paper presents an ongoing project to assess the level of instrumentation, control, and automation (ICA) in Brazilian wastewater treatment plants (WWTPs). The study aims at evaluating the technological and regional disparities and exploring their relationship with automation, efficiency, and costs. A seven-step methodology is employed, including the development of a collaborative questionnaire designed for data collection, ensuring the representation of diverse regional realities. Advanced statistical methods and thematic mapping will be applied to identify patterns, assess geographic disparities, and map barriers to the adoption of automation in WWTPs. The results will allow a detailed overview of the typology of WWTPs by operational characteristics, region and automation level; monitoring practices, instrumentation quality, maintenance frequency, failure history, and existing automation systems. It also will identify critical training needs for operators and managers to enhance the effective operation of automated systems. The study proposes regional indicators to track automation progress and provides tailored guidelines to address local challenges, supporting the modernization of WWTPs.

**Keywords**: ICA; Brazilian WWTPs; automation barriers; efficiency indicators.

Instrumentation, control and automation (ICA) in wastewater treatment plants (WWTPs) are essential to increase efficiency, optimize resource use, and promote global sustainability. Real-time monitoring and advanced process control are crucial (Olsson et al., 2005). In Brazil, ICA has advanced due to the continuous efforts of sanitation companies and the New Legal Framework for Basic Sanitation (2020), which determines 90% sewage coverage by 2033. Despite improvements, barriers, such as outdated technologies, manual processes, and regional inequalities, still limit automation, especially in less developed areas with low sanitation coverage and financial constraints, restricting investments in modern infrastructure. Figure 1 highlights the regional disparities in the distribution of WWTPs in Brazil, with the highest concentration of facilities in the Southeast and South regions. The shortage of skilled labour in automation might also compromise both the operation and maintenance of systems, limiting its application in WWTPs.

This research is motivated by the need to overcome challenges in implementing ICA in Brazilian WWTPs. It seeks to bridge technological and regional differences across the country, promoting the efficient use of resources in WWTPs, with a focus on digitalization and sustainability. The study aims at filling the existing gap of ICA assessment, providing technical support for the development of accessible and effective technological solutions, adapted to different regional realities. The goal is to provide a comprehensive overview of ICA in Brazilian WWTPs, with a focus on both technical and regional aspects, addressing measuring devices, their maintenance and history of possible failures, as well as the analysis of the relationships between automation, operational efficiency, and associated costs. The adoption and attitude toward advanced control systems, simulation software, and digital twins. The mapping of barriers to enhance automation may help in identifying training needs for operational staff and propose regional indicators to track progress in automation and efficiency. The gained insights will ultimately provide valuable guidelines for the modernization and automation of WWTPs in Brazil.

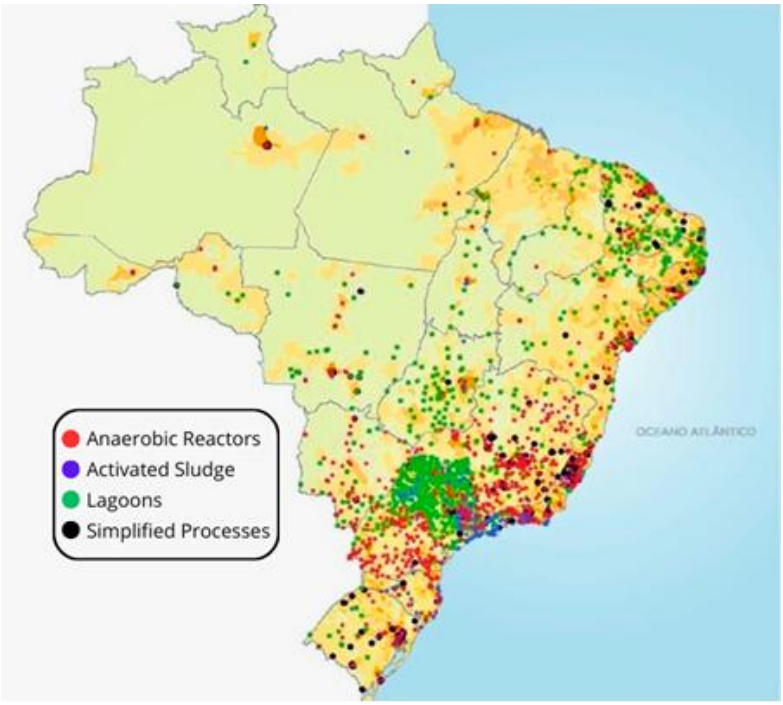


**Figure 1** Distribution of WWTPs in Brazil by typologies. Adapted from the Atlas of Wastewater (ANA, 2019).

The research is organized in seven steps, as summarized in Figure 2.

**Figure 2** Research steps.

The first step, which involves a technical review to identify key factors essential for analysing ICA scenarios in WWTPs in Brazil, has been completed. This review served as the foundation for the study and guided the development of a questionnaire, which constitutes the second finalized step.

Based on this questionnaire, the ICAW$^2$BR24 web application was developed. Figure 3 presents some of ICAW$^2$BR24 interfaces. This collaborative platform is designed to facilitate the efficient collection of data by WWTP managers and operators, simplifying the process of information input. It allows for an active user participation; its accessible interface promotes engagement and ensures that the data collected represents the different realities and conditions of WWTPs in Brazil. At present, ICAW$^2$BR24 is being distributed and filled to plant operators and managers across Brazil.

The fourth stage, which focuses on data collection is currently on going. Following this step, the research will proceed with processing and organizing the collected information. These data will be analysed using advanced statistical methods and thematic mapping, providing a detailed and robust approach (Olsson et al., 2014; Yuan and Olsson, 2019). Correlation analysis, regression,

and hypothesis testing will be employed to explore relationships between variables, such as the operational efficiency of WWTPs and the types of automation implemented. This will help identify patterns and key factors that influence the system performance. Thematic mapping will complement the statistical analysis by visualizing the geographic distribution of WWTPs, their operational characteristics, and regional barriers. This approach will facilitate the identification of disparities and priority areas for intervention, offering valuable insight for improving automation and operational efficiency across different regions.

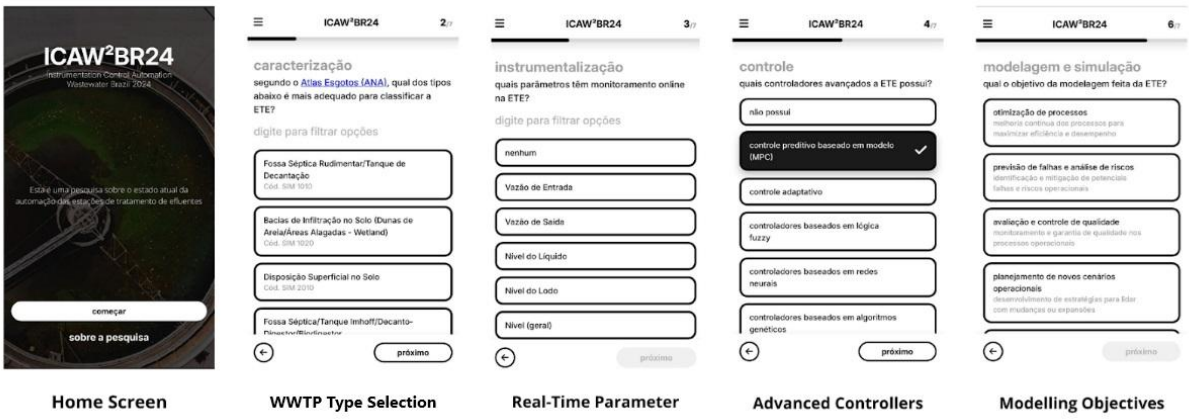


**Figure 3** Interfaces of the ICAW²BR24 application.

Ultimately, the data will be consolidated into relevant insights for the definition of tailored guidelines, offering strategies for sanitation companies to overcome challenges and adopt automation solutions effectively.

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