Chapter 5
Artificial Intelligence as a Sustainable Tool for Optimizing the Wastewater Treatment Plant

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ABSTRACT

The field of artificial intelligence (AI) is advancing at a rapid pace. The evolving technology can replicate practical scenarios in different industries, such as water purification and wastewater treatment. It has demonstrated its value in agriculture, the automotive industry, banking, finance, space exploration, and creative technology. Wastewater treatment has seen significant improvements with the integration of artificial intelligence, which enhances efficiency, speed, and autonomy. Nevertheless, there are notable obstacles and limitations to address, such as data management challenges, interpretability concerns, model replicability and consistency issues, and the need for scholarly transparency. Improving model causality, clarity, data management, and repeatability are proposed solutions. The chapter introduced some of the recent artificial intelligence based optimization methodologies to optimize waste water treatment plants.

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1. INTRODUCTION

It is essential to acknowledge that water encompasses a significant portion of the globe's surface and is vital in sustaining human life. However, only 1% of water is fresh and accessible, and the demand for water on a global scale is predicted to rise from 4200 Bm3 in 2015 to 6900 Bm3 by 2030 (Ng et al., 2015). Industrial activities introduced various impurities and hazardous materials, leading to multiple methods for analysing and forecasting water and wastewater quality (Dubey et al., 2015). Traditional methods, such as linear regression algorithms and computational frameworks, face challenges in understanding systems' intricate non-linearities and complexities. Empirical and statistical regression models can make precise predictions but struggle with water treatment processes' complicated dynamics and nonlinear relationships. It is essential to carefully analyse and fine-tune specific parameters in water treatment, such as 'biological oxygen demand' (BOD), coagulant dosage, and 'chemical oxygen demand' (COD). Traditional testing methods, such as the jar test, are often oversimplified due to assumptions and idealized factors impractical in real-world scenarios. Optimizing process parameters like pressure, temperature, flow rate, and pH is crucial for achieving optimal plant performance in the treatment of wastewater and reuse usage, where membrane technology has emerged as a promising solution. Conventional models in wastewater treatment plants (WWTPs) rely on utilizing mathematical models and empirical relationships for predictive models, which may not be universally applicable due to differences in operating conditions. Studies suggest that the assessment of BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) in water is essential for determining the effectiveness of Wastewater Treatment Plants (WWTPs). In addition, parameters such as total suspended solids, or TSS, and total nitrogen (TN) levels are crucial indicators for assessing the quality of potable and eco-friendly water.

Understanding BOD and COD is crucial in evaluating the oxygen content in wastewater to optimize (Nourani et al., 2018). AI technologies have brought about significant changes in the current industrial sector, known as Industry 4.0, by replicating human intelligence and behaviours in technical systems. AI technologies such as 'deep learning' (DL), 'support vector machine' (SVM), 'artificial neural networks' (ANNs), 'genetic algorithm' (GA), and 'fuzzy logic' (FL) can perform independent evaluation, prediction, and analysis using input data, reducing the likelihood of mistakes, and increasing efficiency. Recent focus in water purification technology has been on coagulation/flocculation, disinfection, desalination, source water analysis, and membrane filtration (Li et al., 2021). AI technologies such as "artificial neural networks" (ANNs) employ a dynamic and data-focused approach. This approach involves three levels: an input layer, one or more hidden layers determined by the algorithm, and an output layer. The output layer computes the weighted mean and

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