Chapter 17
Survey on the Artificial Intelligence and Machine Learning Techniques on the Applications of Wastewater Treatment for Sustainable Environment

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ABSTRACT

Critical water and wastewater treatment applications have been optimized, modelled, and automated using artificial intelligence (AI) techniques and machine-learning models. Also, it describes the cases in which machine learning algorithms have been applied to evaluate the water quality in different water environments, such as surface water, groundwater, drinking water, sewage, and seawater. Wastewater characteristics prediction in wastewater treatment plants (WWTPs) is valuable and can reduce the number of samplings, energy, and cost. The study reviews machine learning, deep learning, and smart technologies used in wastewater treatment for generation, prediction enhancement, and classification

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tasks, providing a guide for future water resources challenges. These models can be used to make decisions in water resources management and governance, but ethics and future directions need to be addressed and focused.

INTRODUCTION

It is crucial to consider all possible measures to lessen the overexploitation of the finite freshwater resources because the globe is currently experiencing a water scarcity problem (Salehi, 2022). One of the crucial sources of water as the population and activity rise[5] is wastewater (Saleh et al., 2022; Müller et al., 2023; Smetana & Grosser, 2023; Salgot & Folch, 2018). It is desirable and technically possible to take a selective approach to multiple wastewater recovery, supplying water that meets precise quality specifications for each reuse goal (Ungureanu et al., 2020). By avoiding needless treatment and long-distance conveyance, this method might conserve water and lower manufacturing costs and energy demand (Giammar et al., 2021). Because of this, it is essential to use the best ways for treating wastewater utilizing artificial intelligence and machine learning techniques (Lowe et al., 2022; Maamoun et al., 2023; Zhu et al., 2022; Bagherzadeh et al., 2021; Sit et al., 2020)

Artificial intelligence (AI) has shown its ability to address the problems associated with the treatment of drinking water (DWT). It helps manage and run DWT processes mechanically, rather than depending on human actions. AI-based data analysis and evolutionary learning methods enable water quality diagnoses, autonomous decision making, and process optimisation (Li et al., 2021).Wastewater treatment is given an example of how to create ANN models in clause (Jawad et al., 2021). Membrane and thermal processes, which account for 65% and 35%, respectively, of the need for freshwater, are used to fill the gap (Kress, 2019). Several membrane technologies, including reverse osmosis, forward osmosis, membrane distillation, microfiltration, ultrafiltration, and nanofiltration, are used in desalination. Wastewater and sewage are treated using the activated sludge technique in a membrane bioreactor with MF and UF (Silva et al., 2023). Mathematical models are necessary for the process' modelling and optimisation. Permeate flow, salt rejection, and membrane fouling are a few of the processing variables for membrane filtration that have received the most attention (Niu et al., 2022). Because of assumption (Badrnezhad & Mirza, 2014), theoretical or transport-based models cannot reliably anticipate these properties. Artificial intelligence (AI) methods, including ANN, fuzzy logic, ANFIS, genetic programming, and support vector machines, offer an alternate method to accurately describe membrane processes(Garud et al., 2020).

A machine learning technique called an artificial neural network (ANN) is based on biological neurones and uses a learning mechanism like that of the human brain to address a variety of issue (Lagaros, 2023). Fuzzy logic is a type of many-valued logic that permits partial truths, enabling us to take errors and uncertainties into account while making decisions. Uses for this technique range from AI and control systems to NLP and medical diagnostics through image processing and computer vision (Esmaeili et al., 2023). To integrate knowledge and learning, ANFIS (fuzzy inference system) combines the best aspects of fuzzy systems with neural networks (Yosif et al., 2022). Genetic programming (GP) is a field of artificial intelligence that uses evolutionary algorithms to find answers to issues that people are unable to solve without the help of human biases or prejudices (Santoso et al., 2018). Non-linear classifier techniques like Support Vector Machine (SVM) are frequently cited as having superior classification performance over other techniques. It maximises the margin of difference between positive and negative examples, leading to improved classification accuracy, by using a hyper plane as a decision surface. SVMs have both a strong theoretical foundation and contemporary success in practical applications (Waqas et al., 2022).