Chapter 7

AI-Based Smart Water Quality Monitoring and Wastewater Management: An Integrated Bio-Computational Approach

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ABSTRACT

Water is unambiguously susceptible to contamination, as it is able to dissolve a broader spectrum of substances than any other liquid on Earth. Increasing population and urbanization have been imposed to monitor water quality and wastewater management in the current global scenario. Conventional water quality monitoring involves water sampling, testing, and investigation, which are usually performed manually and are not dependable. Rapid economic prosperity generates a larger quantity of wastewater enriched with a broad range of pollutants that pose serious threats to the environment and human health. Advancements in artificial intelligence and machine learning approaches have shown breakthrough potential toward large dataset capture and analysis of large datasets to attain complex large-scale water quality monitoring and wastewater management systems. The current chapter summarizes prospects and potentials of AI technologies for the amelioration of water quality monitoring and wastewater management to establish an integrated sustainable biocomputation platform in the near future.

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INTRODUCTION

One of the most important things for leading a healthy lifestyle is to stay hydrated; for that reason, water is very beneficial for human beings. Despite the fact that water covers approximately 71% of the Earth's surface, obtaining clean water for drinking and other essential uses remains a challenge for human civilization (Fishman, 2011). There are many reasons, such as population, industrialization, and water pollution, that are to blame for the escalating daily water crisis. Along with the other causes, water wastage and water distribution also play an important role in this water crisis (Sivakumar, 2011; Jury & Vaux, 2007). From the time of evolution of the human civilization, people had started to use the water more than the requirement, and for that reason, the formation of the wastewater reached up to the usual level, and the level of the fresh ground water has also reached below the acceptance level (Lofrano & Brown, 2010). Consequently, as the global population increases, so does the need for fresh subterranean water (Contreras et al., 2017). The water crisis indirectly indicates an increase in the amount of waste water, which leads to many health deaths, such as malaria and cholera (Marshall, 2011). Therefore, to address all these types of difficulties, critical thinking and progressive approaches for wastewater treatment are among the most important steps to follow (Bhargava, 2016). With this perspective, currently, different biocomputational platforms have taken an important role in different water quality management systems, such as groundwater monitoring, surface water monitoring, and wastewater management (Malviya & Jaspal, 2021; Zaresefat & Derakhshani, 2023; Oruganti et al., 2023). Artificial intelligence is a new technology that is used to perform different types of analytical, statistical, and industrial work without any mistakes at a rapid speed as a replacement for human power (Dwivedi et al., 2021). In water monitoring and management, artificial intelligence (AI) is primarily used to control and monitor several parameters, including biological oxygen demand (BOD), chemical oxygen demand (COD), and concentrations of nitrogen and sulfur (Malviya & Jaspal, 2021). Artificial intelligence (AI) algorithms, including support vector machines (SVMs), artificial neural networks (ANNs), adaptive neurofuzzy inference systems (ANFISs), and deep neural networks (DNNs), have been broadly employed in the monitoring and management of wastewater and various water bodies (Hussain & Naaz, 2020).

The primary data processing models used by artificial neural networks (ANNs) are derived from the way organic nervous systems, such as the brain, handle information. In contrast to SVM, which can solve small samples in terms of nonlinear, high-dimensional, localized minima and other partial elements, artificial neural network (ANN) solutions are applicable to both linear and nonlinear problem types. ANNs build several processing units based on interconnected connections, mimicking the way the human brain analyzes and processes data (Dastres & Soori, 2021; Walczak, 2019). Additionally, it has a modular architecture that permits component design implementation to be performed independently (Yahya et al., 2019). Along with the mentioned models, RF, DNN and many other algorithms have also been proven to have proper functionality in terms of predicting water quality parameters, automating water treatment plants and many other water management processes. Therefore, effective use of AI will be successful in wastewater management and water quality monitoring.

Conventional Approaches for Water Quality Monitoring

Water quality monitoring has come into main focus since the last 19th century for the sudden and enormous appearance of water-borne diseases (İçağa, 2007; Neary et al., 2009; Behmel et al., 2016). There are a number of common ways to monitor water quality, including technology-based approaches and