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Optimizing Water Treatment and Monitoring with AI, Machine Learning, and Smart Technologies: A Review

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ABSTRACT

Introduction: Machine learning (ML), artificial intelligence (AI), and innovative technology are increasingly applied in water treatment and monitoring to optimize processes and address complex challenges. This review article provides an overview of the current applications and advancements in AI, ML, and innovative technology within the water industry.

Search Strategy: PubMed, Web of Science, Scopus, and Google Scholar databases were systematically reviewed using the keywords "machine learning," "artificial intelligence," "smart technology," "water treatment," and "water monitoring." The literature search was limited to include peer-reviewed articles written in English, primarily from 2018 to 2023.

Results: AI methods have been demonstrated to control chlorination effectively. At the same time, ML models are effective in modeling Disinfection By-Product (DBP) concentrations and important parameters for adsorption and membrane filtration processes. The results are often evaluated using various statistical measures, including the coefficient of correlation (R), the coefficient of determination (R2), the mean average error (MAE), the mean square error (MSE), the root mean square error (RMSE), and relative error (RE). ML for adsorption processes has the potential to support operator decisions. Other models that researchers have studied with notable success include Adaptive Neuro-Fuzzy Inference Systems (ANFIS), Support Vector Machine (SVM), and Random Forest (RF). On average, artificial neural network (ANN), support vector machine (SVM), and RF ML models performed well, typically achieving R2 values greater than 0.9 and sometimes exceeding 0.99.

Conclusion and Discussion: The review highlights the increasing adoption of AI, ML, and innovative technology in the water industry, with significant investments expected to drive further advancements in the coming years. While these technologies have successfully optimized water treatment processes and monitored natural systems, challenges such as data quality, model interpretability, and scalability must be addressed to facilitate widespread implementation. Further research and innovation are needed to overcome these challenges and unlock the full potential of AI, ML, and innovative water treatment and monitoring technology.

Keywords: Artificial intelligence, Machine learning, Water