Chapter 11
AI-Driven Wastewater Treatment and Recycling: Smart Water

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ABSTRACT

Life depends on water, yet its management is under more stress than ever. Besides, contamination and the scarcity of water made it impossible to fulfill humans' basic needs. Artificial intelligence (AI) provides revolutionary possibilities through real-time monitoring, statistical analysis, and machine learning, while more than 80% of polluted water worldwide is released untreated. In this chapter, the strategies behind the application of AI in wastewater treatment and recycling are explained. It addresses both opportunities and constraints while striking a balance between creativity and reality. The chapter bridges the gap between technical depth and readable storytelling by referencing industry data, scholarly research, and expert perspectives. It draws attention to how AI is changing water sustainability by transforming wastewater from a liability into a resource.

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INTRODUCTION

Water is one of the fundamental elements for living organisms that can't be replaced with other resources. One of the biggest issues endangering sustainable development in the twenty-first century is global water scarcity. Water scarcity and contamination are escalating daily due to rising demand (Senthil Rathi et al., 2025). The world's population increased tremendously over the past few decades, and rapid industrialization and urbanization have also a direct relation with water scarcity and demand, which leads to an unsustainable, imbalanced ecology (Yalcin & Ayyildiz, 2024). Thereafter, the abundant discharge of untreated wastewater from residential, agricultural, and industrial sectors turns out to be the most predominant source of surface water contamination. The quantity and quality of water sustain ecological equilibrium, which in turn impacts human lifestyle (Baarimah et al., 2024).On the other hand, contaminated water is the main cause of disease and makes the ground unfit for sustaining life. Due to the abundance of good-quality water supplies and their accessibility, water quality concerns have frequently been disregarded. Rapid growth in the industrial and agricultural sectors is being fueled by the world's expanding population, which raises the need for water, which is essential for supporting all life. The main sources of water for industry, agriculture, and human and animal use are rivers, groundwater, and lakes. However, in many parts of the world, climate change is increasing the frequency of floods and droughts (Chavhan et al., 2025). Furthermore, the amount and quality of drinkable water are being significantly deteriorated by water pollution from a variety of sources, including families, towns, farms, and industrial operations. As a result, increasing the quantity and quality of drinking water requires that effluent be properly treated before being released into bodies of water.

While the past few decades have driven rapid development across sectors, unforeseen future challenges, particularly in water management, loom large. As a consequence, the future is in danger if necessary steps are not taken for the sustainability of water and water management. Water is a key component for agriculture, industry, and households, but this demand can't be fulfilled with traditional management and technologies; hence, advanced technologies like machine learning and artificial intelligence are needed. These technologies offer a robust and user-friendly system that can be operated far from the site and also offer an easy way to monitor the water treatment system and the recycling process.

Smart cities are leading the way in tackling these sustainability concerns by utilizing digital technology to enhance urban administration. For cities to continue to be resilient, livable, and ecologically friendly, effective water resource management is essential. Sustainable wastewater management and water use techniques help to lessen the negative consequences of climate change, conserve natural resources, and

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