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REVIEW ARTICLE



Industrial revolution 4.0 in water supply, wastewater and stormwater management: opportunities, challenges, and impacts

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ABSTRACT

Industrial Revolution 4.0 (IR 4.0) is the revolution that promotes customized and flexible mass production technologies in automation and manufacturing processes. The application of industrial revolution 4.0, such as the Internet of Things (IoT), Cyber-Physical System (CPS), and big data, are used in the water industry to provide better water quality, accurate real-time data, etc. This paper compiles IR 4.0 technology applications, advantages, disadvantages, impacts, and challenges in the water sector, including water supply, wastewater treatment, and stormwater management. It is found that the current water industry is facing a few challenges, such as managing water services, balancing water costs with energy prices, maintaining aging water and wastewater infrastructure, and environmental issues. However, with the application of numerous IR 4.0 innovations, all the challenges can be solved or minimized. Meanwhile, the advantages and impacts of adopting IR 4.0 in water industries are thoroughly discussed. Despite the numerous advantages of IR 4.0, significant drawbacks have restricted the adoption of IR 4.0 in the water industry. The high start-up cost, reluctance, uncertainty, and problems of adopting IR 4.0 are some key challenges that need to be addressed. Generally, IR 4.0 provides more benefits to the community as it helps improve the water system's performance and efficiencies and creates a more sustainable environment.

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1. Introduction

The industrial revolution (IR) is a process of change from agrarian-based structures to machines and manufacturing or a complete transitional shift in the economic and social networks of the current community due to technologically advancing alternatives that improve efficiency. The first industrial revolution (IR 1.0) began in 1784, focusing on the mechanization of manufacturing with the introduction of water and steam power. A Scottish inventor named James Watts came up with a sustainable version of the steam engine [1]. After Watt's innovation, many industries applied his invention for their purposes, such as using steam engines to process yarn in a cotton mill, mechanized farming, and steam trains that eventually led to railroad connections. This revolution is known as The Age of Mechanical Production [1].

In the 1870s, more inventions emerged alongside scientific discoveries, such as electricity, chemical

fertilizers, and gasoline-powered engines. Then the second industrial revolution (IR 2.0), known as The Age of Science and Mass Production, was started in 1879, using electrical power for mass production assembly [1]. Many people left their rural homes to search for job opportunities in cities, which eventually sparked urbanization in bigger towns and led to the beginning of a modern world.

IR 3.0 was introduced in 1970 and focuses on digital technologies and Information Technology, using Internet Access to do a human's work using Programmable logic controllers (PLC), hence earning the name The Digital Revolution [2]. The digital age brought 1950 global communication, thus enabling supply chains and business opportunities to reach a global range.

IR 4.0 started in 2011 to transform modern society and innovation with advancements in digitization, automation, data analysis, and interconnectivity to drive the economy. The primary function of IR 4.0 is to