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Views & Comments

Creating Smart Waterworks to Produce Healthy Drinking Water

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Water is the source of life and health. As living standards continue to improve, the public is becoming increasingly concerned about the safety of drinking water, which is closely related to human health [1]. The design and operation of public waterworks, which are seen as a key link in ensuring the safety of drinking water, are essential in promoting the healthy development of human life, the economy, and society. The following problems are currently affecting drinking water safety in China:

(1) Due to serious levels of micro-pollution, the difficulties in maintaining safe drinking water quality have increased. The use of groundwater as a drinking source has suffered from poor water quality [2].

(2) A combined pollution pattern is found in drinking water, which includes combinations of pollutants, combinations of polluting processes, and combined effects of pollution.

(3) Limitations exist in traditional water purification processes, which make it difficult to combine the existing design and layout of waterworks equipment with new technology [3]. Emerging pollutants such as microplastics, endocrine-disrupting chemicals (EDCs), pharmaceuticals and personal care products (PPCPs) [4], perfluoroalkyl substances (PFAS) [5], and disinfection byproducts are frequently detected in water circulation systems [6], preventing traditional water purification processes from fully meeting water quality standards.

(4) Water pollution problems caused by sudden water pollution accidents and natural disasters threaten drinking water safety [7]. Emergency water protection systems to address such scenarios are not complete.

(5) Drinking water transportation and distribution processes are not developing in a balanced way, and online monitoring systems for water quality in water sources have not yet been sufficiently improved. Water transmission and distribution networks are operating at the limit of their capabilities, resulting in high energy consumption and secondary pollution [8].

For these reasons, it is necessary to rethink and optimize the water supply system in practice, in order to build future waterworks with more innovative and integrated principles.

The goal of future waterworks construction is to further improve the safety and reliability of waterworks operation while reducing energy usage and water consumption, in order to guarantee the quality of the water supply. The corresponding design of future waterworks should have the following four key characteristics: modularization of the purification unit, "greening" of the purification process, reuse of recovered material, and intelligentization of the control mode.

(1) For modularized design, the water quality characteristics of the water sources should be fully analyzed in order to optimize the appropriate equipment and combination of processes, and enable a smooth connection between the main process and auxiliary process modules [9]. Each module should be able to replace every other module, which will facilitate maintenance and improve the emergency response capability of the whole process. Improvements in the flexibility and expansibility of the process must be oriented toward future developments, in order to facilitate phased investment construction and minimize duplicate investment in the reconstruction and expansion of waterworks.

(2) For water purification processes, it is necessary to choose green equipment and water purification technologies as far as possible in the design stage of waterworks facilities. Renewable energy can be utilized in this endeavor, such as the wind and solar energy available in the local environment. It is necessary to realize energy recovery and reuse in the production process in order to reduce energy consumption and environmental pollution. Few or no chemicals should be added during the water treatment process; instead, physical purification processes should be adopted as much as possible, in order to ensure that the quality of the effluent is stable and up to standard, and to reduce the risk of secondary pollution of the effluent. The new membrane separation technology that has been adopted in core treatment units for advanced water treatment has shown excellent results in the removal of emerging pollutants [10].

(3) In order to reduce the dosage of chemical agents and realize source control of sludge and other byproducts, future waterworks designs should focus on the recirculation and reuse of wastewater and wastes from production at each node of the process flow. For example, this may include the retreatment of the water-based solution of concentrated pollutants produced during membrane treatment, in order to realize near-zero discharge of wastewater and wastes from the treatment processes, and thereby reduce the environmental impact of the processing facility. Furthermore, it is recommended to expand the scope and field of the utilization of recyclable resources, in order to achieve as much recycling of byproducts as possible. Harmless utilization of byproducts or energy recovery can be considered as a way to deal with sewage sludge. One effective means of sludge disposal is the combination of waterworks with municipal wastewater treatment plants for sludge treatment and disposal [11,12], in order to realize

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sustainable development with sludge resource recovery, energy self-sufficiency, and carbon neutralization in the future [13].

(4) Through the comprehensive utilization of big data, the Internet of Things, robots, and innovative breakthroughs in water treatment technology, it is desirable to predict users' demands for water quality and quantity using big data, allocate reasonable disposal processes for different water sources, and distribute water with different grades of quality to users with different demands through intelligent management. In this way, waterworks can achieve the goals of water source diversification, process flexibility, multi-level quality, intellectualization of management, and localization of core equipment, and become an even more essential urban infrastructure for ecological integration. Intelligentization of the control mode will occur on three levels: automation of the control process, intelligentization of the management process, and interconnection of the communication process. Through the interoperability of these three levels, integration of the overall management and control of waterworks will eventually be achieved.

The creation of cutting-edge intelligent waterworks—which is the main objective and task in ensuring the safety of public drinking water—would help to accelerate the construction of an ecological civilization and to realize the construction of a more beautiful environment, both in China and around the world. The construction of future-oriented intelligent waterworks for advanced water treatment is a complex and systematic project, which involves not only numerous professional fields, but also a variety of application technologies. The design and construction of future waterworks must be carried out under the guidance of green development while closely adhering to the characteristics of the times—namely, interconnection, intelligence, and efficiency—in order to meet modern society's demand for water supply in general and drinking water in particular.

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