Towards Closed-Loop Water Management: Process Analysis of AOP-Membrane Systems in Municipal and Industrial WWTPs

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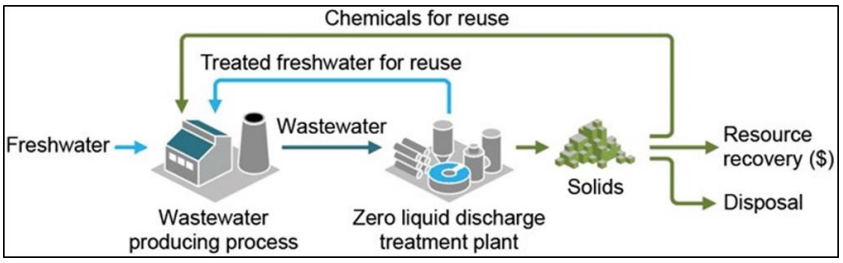
Water scarcity is one of the most serious global threats to human existence and sustainable development. According to a United Nations study, billions of people live in places with high water stress or suffer from severe seasonal water scarcity. It is expected that by 2030, there will be a significant increase in the number of people experiencing water stress in their communities. This reality necessitates a fundamental shift in the water management system to become more adaptable to issues such as scarcity or drought. It is commonly acknowledged that there is a need to transition from an "open" water management system, in which quality water is released into the environment after consumption, to a "closed" system that encourages water recovery and reuse. Reusing cleaned wastewater is critical for sustainable development and the circular economy. Several studies have found that water reuse is an ancient technique, but modern issues necessitate the employment of innovative technologies to ensure the safety and purity of recovered water. However, the quality of water treated using conventional methods is insufficient to ensure the quality and safety criteria required for reuse. It is thus vital to employ advanced techniques. Advanced oxidation processes (AOPs) are one of the most promising strategies for reducing more persistent pollutants. AOPs produce highly reactive radical species and are very effective in degrading low-biodegradable organic molecules that may remain in effluent from conventional wastewater treatment plants (WWTP). Several experiments conducted by this research group have established the synergistic action of AOP used in hybrid configurations, combining different techniques. In this work, we present the findings of process analysis for numerous WWTPs, both municipal and industrial. The treatment schemes typically include a biological treatment, membrane filtration for pollutant concentration, and AOPs for pollutant degradation or refined treated water. In some cases, process analysis involves recovering compounds of interest. Process simulation tools like Aspen Hysys and SuperPro Designer are used to optimize the technical and economic efficiency of water treatment processes while minimizing energy and water consumption.



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