Hydro Link Smart-Fusion: Autonomous Water Purification Modularity System With ML-Optimized Adaptive Decontamination

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Fresh water is earth's most critical resource. Key limitations in water purification include reliance on external power, lack of between microbial disinfection and electrochemical decontamination integration, absence of adaptive process control and limited portability. To address these issues, an Autonomous Flow-Driven Photoelectrochemical Water Accumulative Decontamination System is proposed, integrating multi-stage treatment, a modular block-based design, and Machine Learning-enhanced purification assessment and optimization. Empirical calculations estimate a 5.3-min. purification time to achieve 95% heavy metal removal and 98% bacterial load reduction in 100ml of contaminated water. Efficiency is defined by electrode-based ion removal and UV-C disinfection, with heavy metal filtration as the rate-limiting step. The system utilizes hydrokinetic energy conversion via micro-rotational elements, powering UV microbial inactivation, capacitive deionization for heavy metal reduction, and oxidation-reduction cycling for organic pollutant removal (PAHs, pesticides, POPs). Machine Learning enables real-time optimization, autonomously regulating electrode potential cycles, UV-C intensity, and electrochemical reaction dynamics based on water quality variations. A 2-5V electronic potentiometer adapts to contamination levels from <100 ppm (low) to >1000 ppm (high). The modular design supports diverse applications, from portable field use (rivers, taps, rainwater) to high-throughput industrial treatment, ensuring scalability, cost-effectiveness and energy efficiency. Unifying photoelectrochemical purification, hydrokinetic energy automation and computation, the system establishes a self-regulating, high-portability solution, advancing decentralized, self-sustained water treatment.

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