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Hybrid Biophilic–Inorganic Filtration System for Remote Natural Water Sources: Development and Performance Assessment

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Abstract: *Water pollution in remote and isolated natural water sources continues to pose a major challenge because of the lack of reliable electricity, inadequate infrastructure, and limited access to advanced water treatment facilities. Conventional water purification technologies are often unsuitable for these regions, as they require continuous energy input, regular maintenance, and significant operational expenses.*

This research proposes a hybrid water purification system that combines biophilic and inorganic treatment techniques to improve water quality in a sustainable and efficient manner. The biophilic treatment stage relies on natural plant-based and microbial processes to decompose organic pollutants and enhance biological purification. The inorganic treatment stage incorporates multiple purification mechanisms, including sand filtration, activated carbon adsorption, and membrane filtration, to eliminate suspended particles, dissolved contaminants, harmful chemicals, and disease-causing microorganisms.

The proposed system is designed and evaluated using a combination of engineering design principles, mathematical modelling, computer-based simulations, and prototype experiments. Its performance is examined under different environmental and operational conditions to determine its reliability, treatment efficiency, and adaptability in real-world scenarios.

Experimental and simulation results demonstrate that the hybrid system achieves high purification performance, with substantial reductions in total dissolved solids (TDS), turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and microbial contamination. Furthermore, the system operates with minimal energy requirements and lower maintenance costs, making it economically feasible for long-term use.

The findings suggest that the proposed hybrid purification system provides an effective, sustainable, and affordable solution for improving water quality in remote and resource-limited areas. Its simple design, low operational cost, and environmentally friendly treatment approach make it a promising alternative to conventional water purification technologies for decentralized and off-grid applications..

Keywords: Biophilic filtration, hybrid water treatment, natural water bodies, inorganic filtration, sustainable purification, low-energy systems