Dual-Purpose Biological Photovoltaic: Optimizing Power Output and Wastewater Treatment

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Only half of global wastewater is treated—dropping to just 4.3% in low-income countries—while treatment consumes 4% of global electricity. With the energy sector already accounting for 75% of global emissions, building clean energy solutions for safe water access is crucial. This project developed a novel dual-purpose biological photovoltaic (BPV) to address both challenges simultaneously. A BPV is a device that converts solar energy into electrical energy through photosynthesis, while filtering nutrients and heavy metals from wastewater through cyanobacterial processes. For this project, Arthrospira platensis was employed as the photosynthetic organism due to its efficiency in previous research as well as its adaptability in various environmental conditions. This research sought to improve performance by optimizing electrode surface area and electrolyte type, as well as develop a multi-iterative design for wastewater treatment. The dual-purpose BPV system achieved an average efficiency of 97% for nutrient filtration and 84% for heavy metal removal. Aluminum wool and carbon fiber electrodes, offering the greatest surface area, resulted in the highest power output. Using A. platensis as the electrolyte also increased electron transfer, improving energy generation. When scaled to 22.5 cubic meters, the dimensions of a small-sized wastewater treatment plant, the system is calculated to treat 10,000 liters of wastewater annually with a surplus of 3.2 kWh. With a projected 58-year lifespan, construction based on recyclable materials, and downstream applications for A. platensis, the energy-positive dual-purpose BPV offers an affordable and decentralized solution that can provide clean water and electricity to underserved communities worldwide.

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