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Treatment of Dairy Wastewater and Electricity Generation by Integrating Constructed Wetland with Microbial Fuel Cell

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Abstract: *Dairy wastewater presents a significant environmental challenge due to its high concentrations of organic matter, nutrients, and suspended solids. Conventional treatment methods, while effective in pollutant removal, often involve energy-intensive processes that generate excess sludge and require substantial operational costs. With the growing demand for sustainable and energy-efficient technologies, integrating constructed wetlands (CWs) with microbial fuel cells (MFCs) emerges as a promising solution. The growing demand for sustainable wastewater treatment technologies has led to the exploration of hybrid systems that combine ecological treatment with energy recovery. Dairy wastewater, characterized by high organic load, nutrients, and suspended solids, presents a significant environmental challenge if discharged untreated. This study investigates an integrated system that combines a constructed wetland (CW) with a microbial fuel cell (MFC) to simultaneously treat dairy wastewater and generate electricity. The constructed wetland acts as a biofilter to reduce pollutants, while the microbial fuel cell harnesses the metabolic activity of electrogenic bacteria to convert organic matter into electrical energy. This study investigates the performance of a hybrid CW-MFC system in simultaneously treating dairy wastewater and generating electricity. The constructed wetland acts as a natural biofilter, facilitating the removal of contaminants through physical, chemical, and biological mechanisms, while the microbial fuel cell component utilizes electrogenic bacteria to oxidize organic matter and convert chemical energy into electrical energy. Experimental analysis was conducted using synthetic and real dairy wastewater under varying operational conditions, including different hydraulic retention times, electrode materials, and plant species.The results demonstrate that the CW-MFC system effectively reduces pollutants such as BOD, COD, and nutrients while generating a measurable amount of electricity. The hybrid system not only enhances wastewater treatment efficiency but also contributes to renewable energy generation. This integrated approach offers a cost-effective, environmentally friendly alternative to conventional wastewater treatment methods, with significant potential for scalability and rural application*

Keywords: Dairy wastewater, constructed wetland, microbial fuel

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