Evaluation of Bioelectrochemical Systems for Wastewater Treatment and Energy Recovery at DC Water Blue Plains

Aaron Leininger and ***Birthe Kjellerup*** (bvk@umd.edu) (University of Maryland, Department of Civil and Environmental Engineering)
Mark Ramirez (DC Water)

Background/Objectives. Microbial fuel cells (MFCs) and microbial electrolysis cells (MECs) are bioelectrochemical devices that can recover useful energy from wastewater in the form of electricity or biogas while performing simultaneous water treatment and reducing emissions of greenhouse gasses associated with conventional wastewater (WW) treatment. At the present time, almost all WW MFC/MEC research has focused on primary clarifier effluent or raw wastewater as feedstock, but other higher strength process streams containing higher levels of organics and dissolved solids may provide a greater potential for net energy benefit, defined as the sum of treatment energy savings and energy recovery. As a first step towards development of a pilot-scaled system at DC Water, different blends of process streams were tested for energy recovery potential in bench scale MFCs and MECs. These results were used to inform the feedstock of a pilot-scale MFC installation which is currently beginning operation at the DC Water Blue Plains Advanced Wastewater Treatment Plant.

Approach/Activities. To determine WW feedstock stream, bench scale MFC and MECs with respective volumes of 300mL and 3.5L were operated in batch mode with primary effluent, final-solids-dewatering filtrate, a 60:40 (primary effluent:filtrate) blend and a 1 g/L sodium acetate positive control. With each feedstock, an open circuit duplicate was also operated as a control to the treatment of WW organics, measured as change in chemical oxygen demand (COD). Energy recovery was quantified as energy dissipated across an external resistor (MFC) and energy content of biogas produced (MEC). The relative performance of each feedstock was evaluated by a net-energy-benefit approach which considered the sum of treatment energy savings and energy recovery less the energy input. The 800L pilot-scale MFC installation is based on a 10% dimensional scale of an existing secondary (aeration) reactor at the plant. The system includes 5 insertable electrode modules configured in plug-flow mode. In addition to monitoring energy recovery and WW treatment performance, anodic and cathodic biofilm community structure and dynamics will be studied throughout the course of the study.

Results/Lessons Learned. The bench-scale study suggested that MFCs provide a greater net energy benefit with higher strength WW blends containing more filtrate. Since the relative value of treatment energy savings is much higher than energy recovery in MFCs, the higher COD removal observed with filtrate and the 60:40 blend led to a higher net energy benefit than primary effluent. In the MEC experiment, net energy benefits were similar across all WW feedstocks, but with energy recovery 2-3 times higher with primary effluent as compared to filtrate or 60:40 and treatment energy savings higher with higher strength feedstocks. The MFC pilot system has to date been operated in batch-reactor mode for startup, but at the time of presentation data from the flow through system including power densities, COD and nitrogen treatment efficiencies, and microbial community analysis will be discussed, as well as an energy balance of Blue Plains Advanced Wastewater Treatment Plant with incorporation of MFCs.