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Investigating the Potential of Integrated Plant-Sediment and Microbial Fuel Cell Technology for Water Reclamation and Power Production

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Introduction/Background:

- Many industries (petroleum, pharmaceutical, dairy, food, etc.) produce wastewaters containing high levels of organic matter that can be treated by the plant sediment microbial fuel cell (PS-MFC) technology.
- Plant sediment microbial fuel cell process is a green and energy sustainable technology that uses electrogenic bacteria to break down organic matter while generating power.
- The electricity produced by the PF-MFC process can be used to supply power to run the air and wastewater pumps , making the system self-sufficient and sustainable.

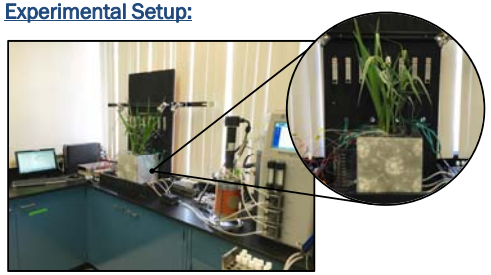
Research Objectives:

- Determine the effect of different variables such as plant and sediment types on the performance of the PS-MFC system.
- Assess the ability of the PS-MFC to treat wastewater and to concomitantly generate power for system sustenance
- Investigate the ability of aquatic plants to remove nitrates and phosphates in water reclamation.
- Identify the microbial species in the PS-MFC by using PCR-DGGE technique.

Description:

- Wastewater (organic carbon source) and nutrients are pumped into the bioreactor, providing the bacteria in anodic region with the necessary food.
- Anode is surrounded by sediment and placed in an anoxic environment.
- Cathode is placed in an aerobic environment, with oxygen provided by air pumps and plants. Oxygen serves as the electron acceptor.
- Air pumps run by solar collector as well as plants provide the required oxygen supply .
- Voltage is generated by the electrical potential difference between anode and cathode

Experimental Setup:



Results

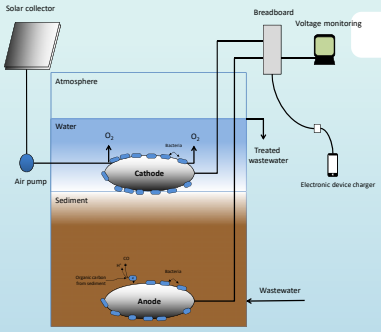


Figure 1. PS-MFC without plants

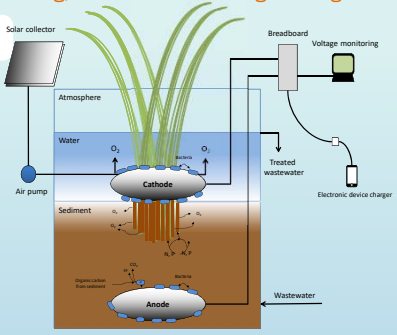


Figure 2. PS-MFC with plants

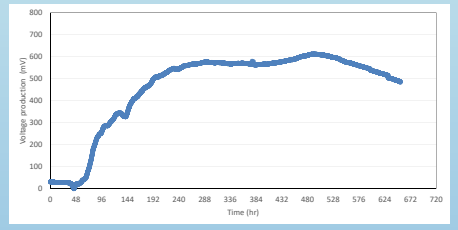


Figure 3. Voltage production without plants (typical of 4)

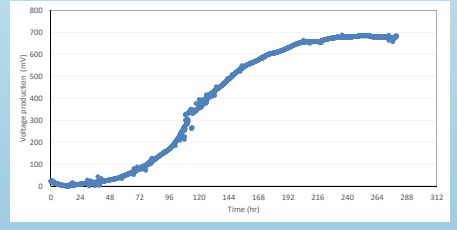


Figure 4. Voltage production with plants (typical of 4)

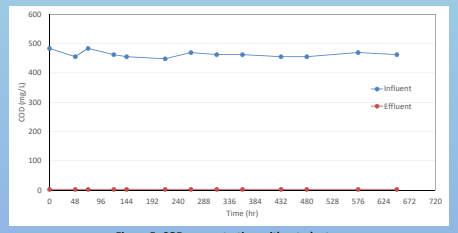


Figure 5. COD concentration without plants

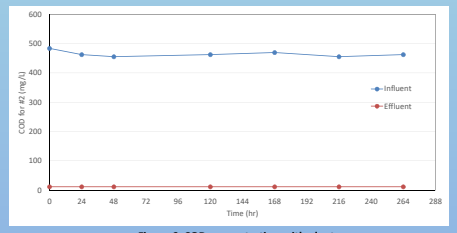


Figure 6. COD concentration with plants

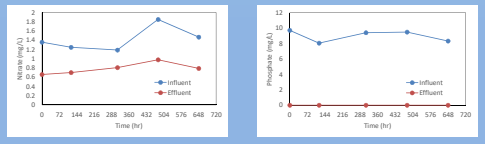


Figure 7. Nitrate and phosphate removal pattern without plants

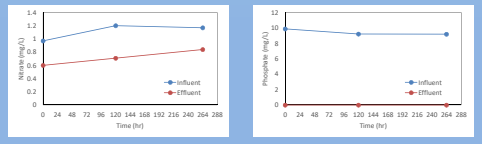


Figure 8. Nitrate and phosphate removal pattern with plants

PCR- DGGE analysis of microbial communities in the sediment used for this study (see figures below)

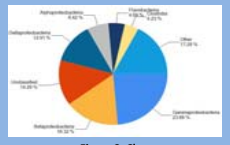


Figure 9. Class

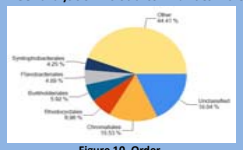


Figure 10. Order

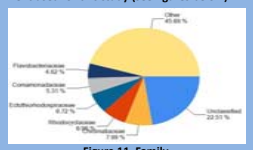


Figure 11. Family

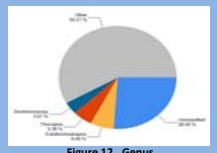


Figure 12 . Genus

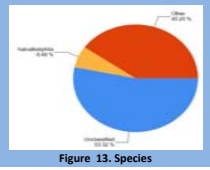


Figure 13. Species

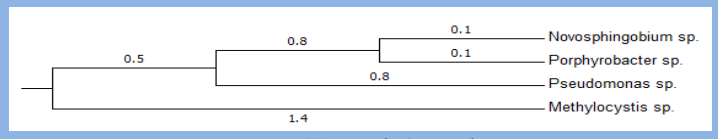


Figure 14 .Phylogenic tree (work in progress)

Discussion:

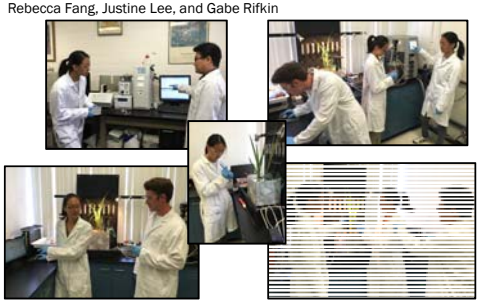
- The PS-MFC system showed high COD removal efficiencies exceeding 99 percent, demonstrating its utility as a green and energy sustainable technology for wastewater treatment (work in progress).
- Factors influencing voltage production include the oxygen level and nutrient concentration in the bioreactor influent wastewater .
- Addition of acetate led to greater bacterial activity, and thus increased voltage production.
- Insufficient oxygen, electron acceptor, in the oxic layer resulted in a drop in voltage production.
- Activated carbon can be used to increase biofilm area and to enhance electron transfer.
- The removals of phosphate and nitrate ions were as high as 100 and 40 percent, respectively.
- Microbial communities in the sediment were investigated by the PCR-DGGE analysis (work in progress).

Future Work Recommendations:

- Different microorganisms may be introduced into the PS-MFC system and their potential evaluated.
- Use PCR and Next Gen genomic methods to identify and isolate the most efficient electrogenic bacterial species and use them as dominant species for optimizing power generation.
- Different plant species can be tested and their potential evaluated.
- Sediments from different wetlands may also be compared for optimizing the PS-MFC system.

Researchers in the Lab:

Rebecca Fang, Justine Lee, and Gabe Rifkin



Acknowledgements:

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