



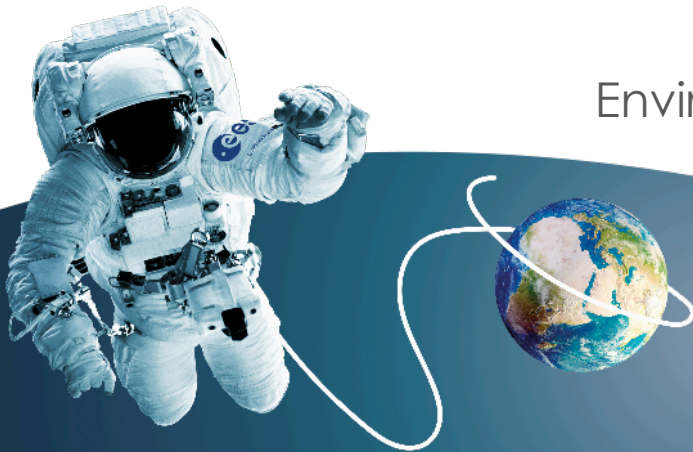
CREATING
A CIRCULAR
FUTURE

Microbial Fuel Cells with Peroxide Production for Blackwater Treatment

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Acknowledgments



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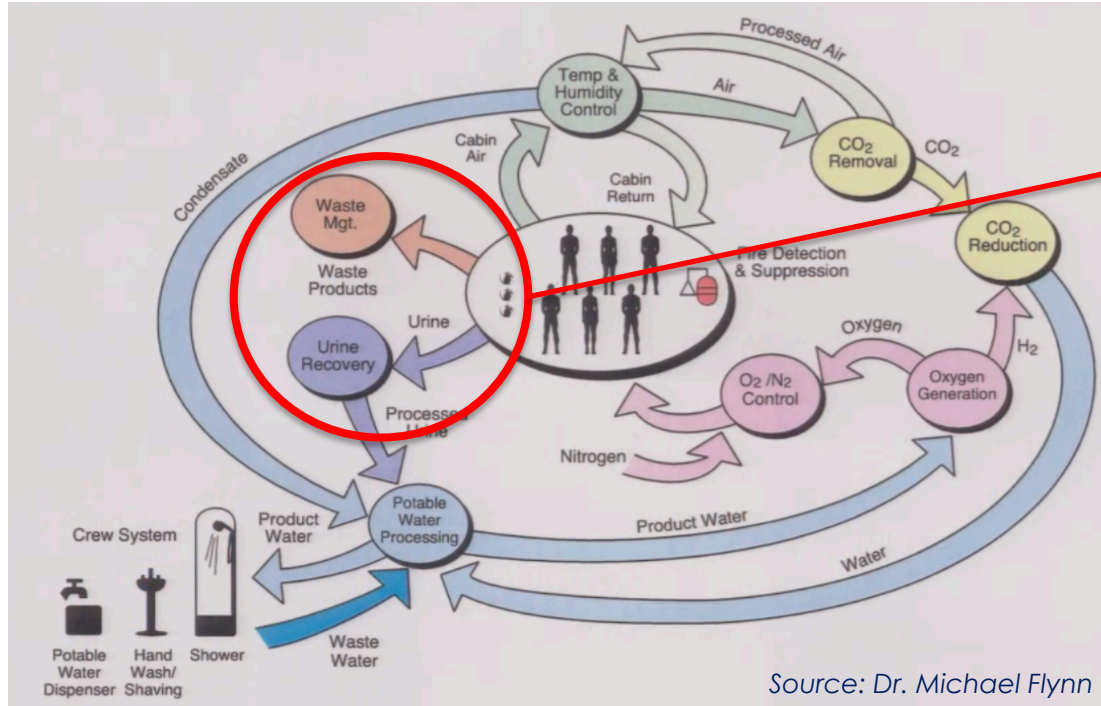
*NASA Ames
Research Center*

Funding





Wastewater Treatment as an Important Component of Life Support Systems in Space



Source: Dr. Michael Flynn

Significant amount of energy in chemical oxygen demand (COD) in blackwater (solids + urine)

How to recover this energy while stabilizing solids and recovering water?

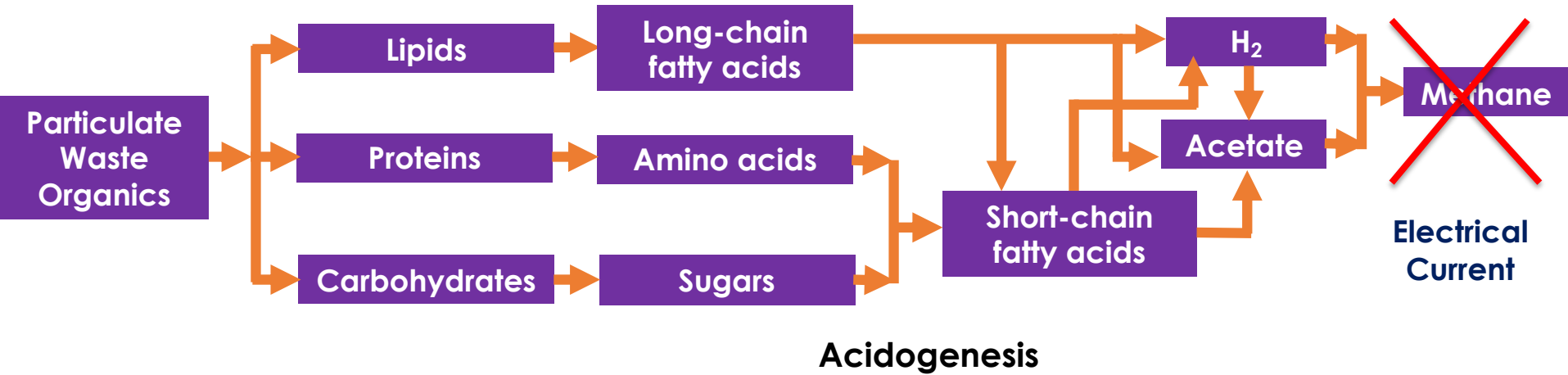


Anaerobic Food Web

Hydrolysis

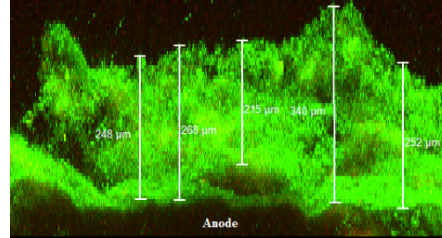
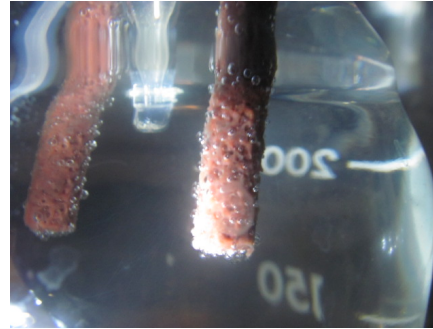
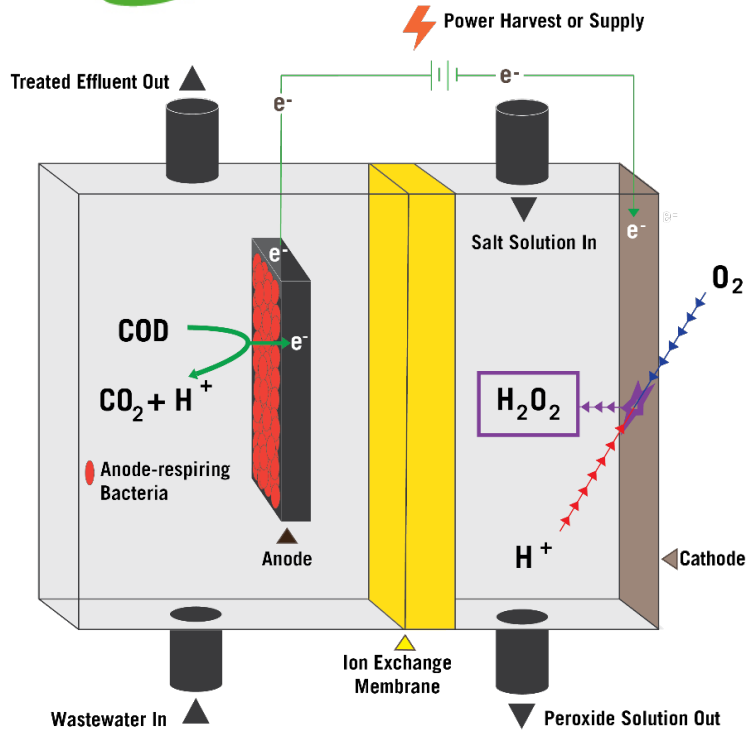
Fermentation

Acetogenesis





Microbial Fuel Cells

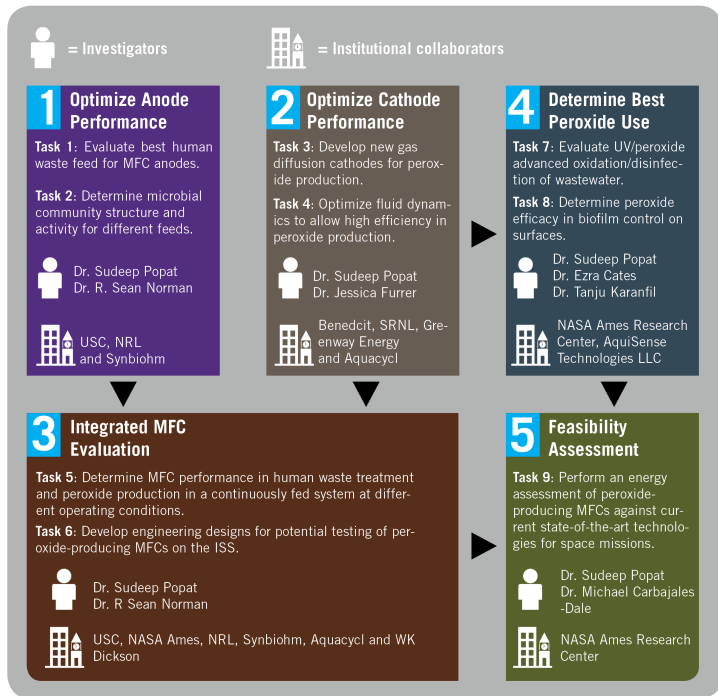


Electrical current production by anode biofilms

Parameswaran, **Popat** et al., *Environmental Science & Technology*, 2013
 Lusk, **Popat** et al., *Bioelectrochemistry*, 2017



NASA-funded Project at Clemson

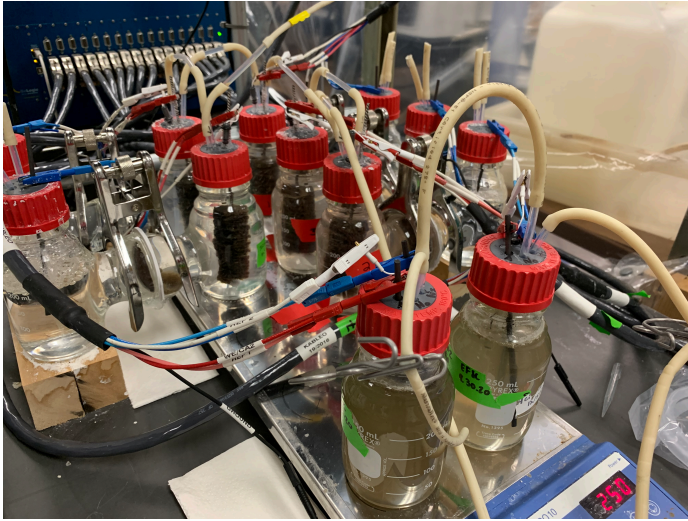


3-year project focused on:

- 1) Optimizing individually anode and cathode performance
- 2) Testing modular MFCs for blackwater treatment with peroxide production
- 3) Performing feasibility assessment for overall concept

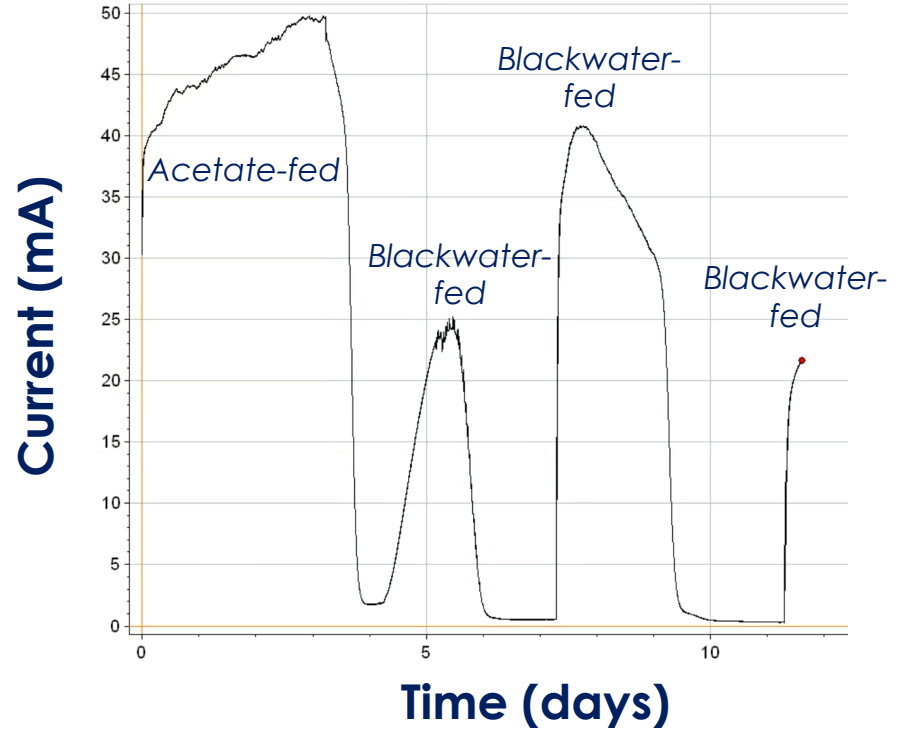


Testing Anode Performance with Synthetic Blackwater



Lab-scale microbial electrolysis cells for evaluation of anode performance

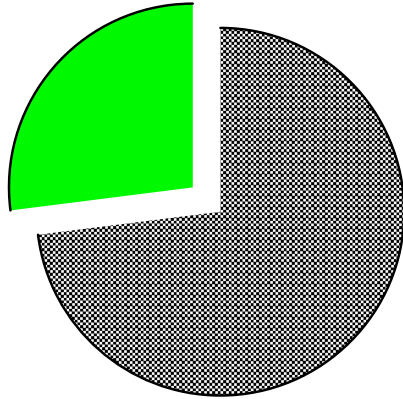
Anodes made with carbon-fiber brushes to achieve high surface area electrodes





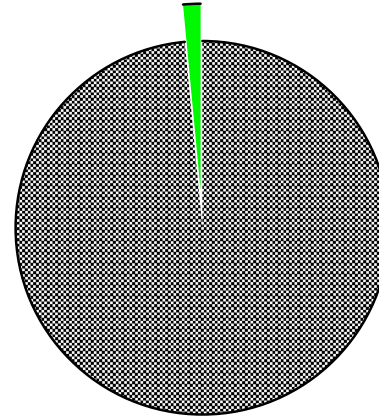
Importance of Avoiding Methanogenesis: COD Balance

Without ammonia



■ 73.00% To electrons
■ 27.00% To methane

With ammonia



■ 98.50% To electrons
■ 1.50% To methane

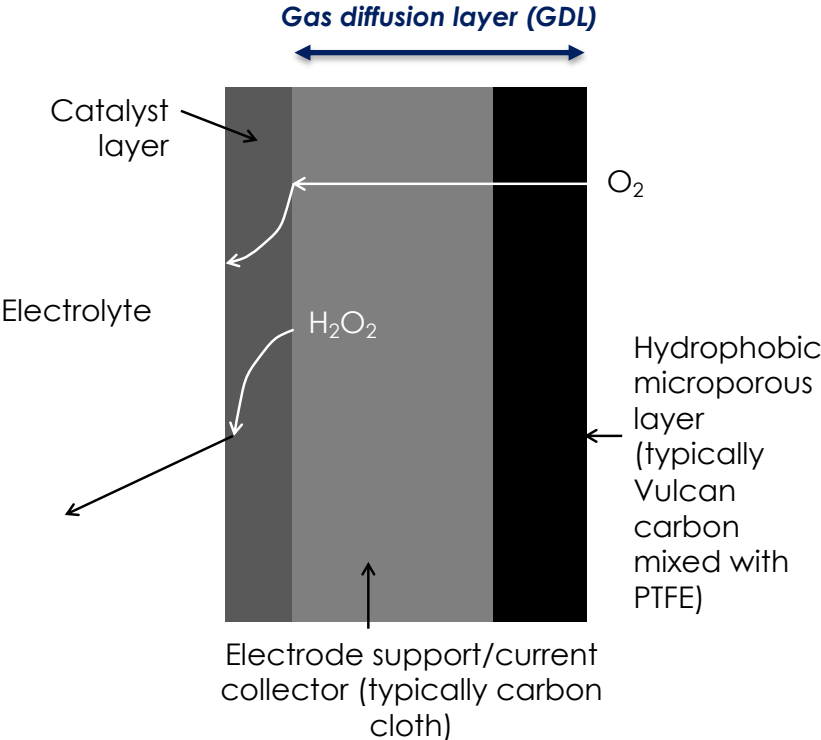


Understanding Factors that Affect Cathodic Peroxide Production

Cathode Reaction:



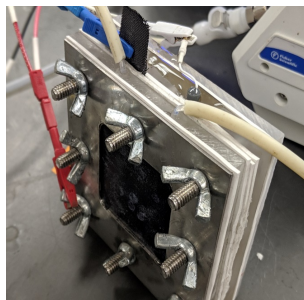
Reaction can be catalyzed on carbon black electrodes



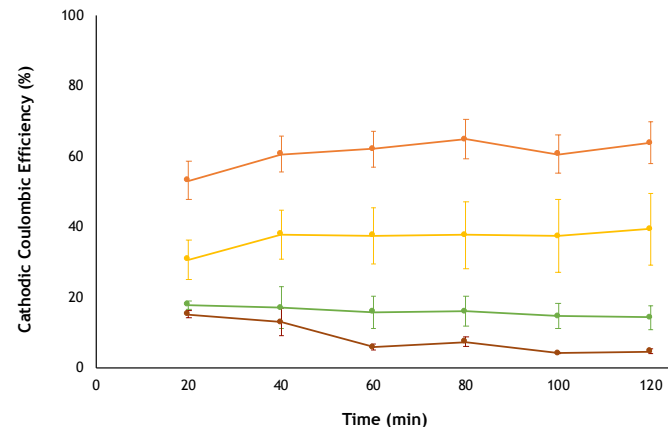
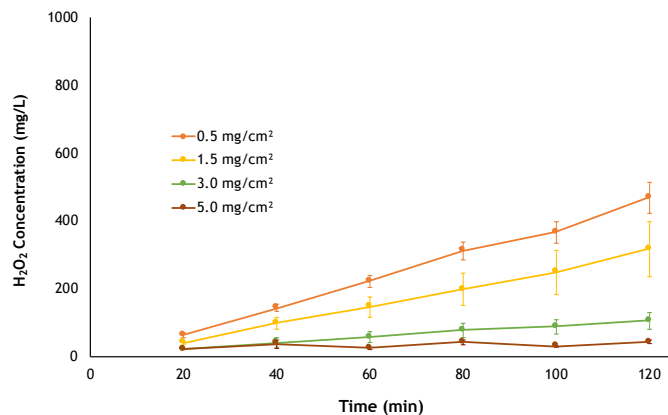
Electrocatalyst Loading Effects on Peroxide Production



Gas-diffusion cathode

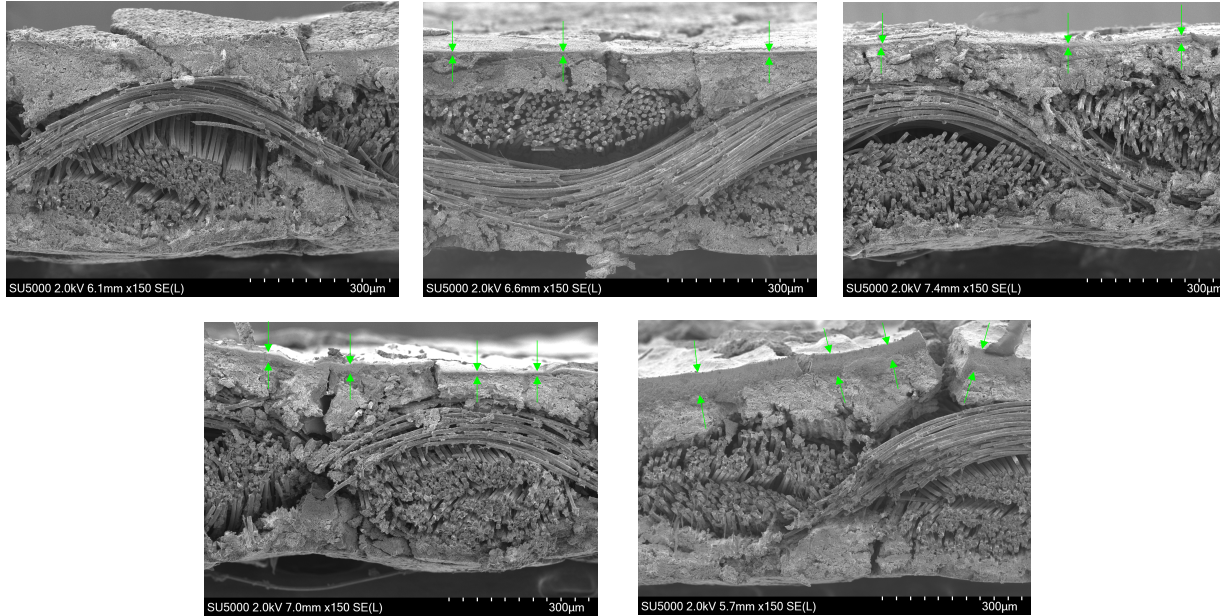


Gas-diffusion half-cell



At 0.5 mA/cm², increased carbon black loading leads to lower efficiency of peroxide production

Electrocatalyst Loading Effects on Peroxide Production



SEM images of cathodes show clear carbon black layer on the GDL, with increasing thickness with increasing loading



Take-home Messages

1. Microbial fuel cells could provide an opportunity to produce peroxide from energy content of wastewater during space missions
2. Anode performance in current production relies on high-surface area electrodes and avoidance of methane production
3. Cathode performance in peroxide production can be improved by decreasing electrocatalyst loading

MELISSA



MICRO-ECOLOGICAL
LIFE SUPPORT SYSTEM
ALTERNATIVE

THANK YOU.

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