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Microbial Fuel Cell Possibilities on American Indian Tribal Lands

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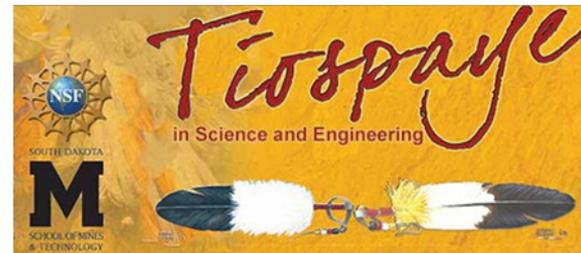


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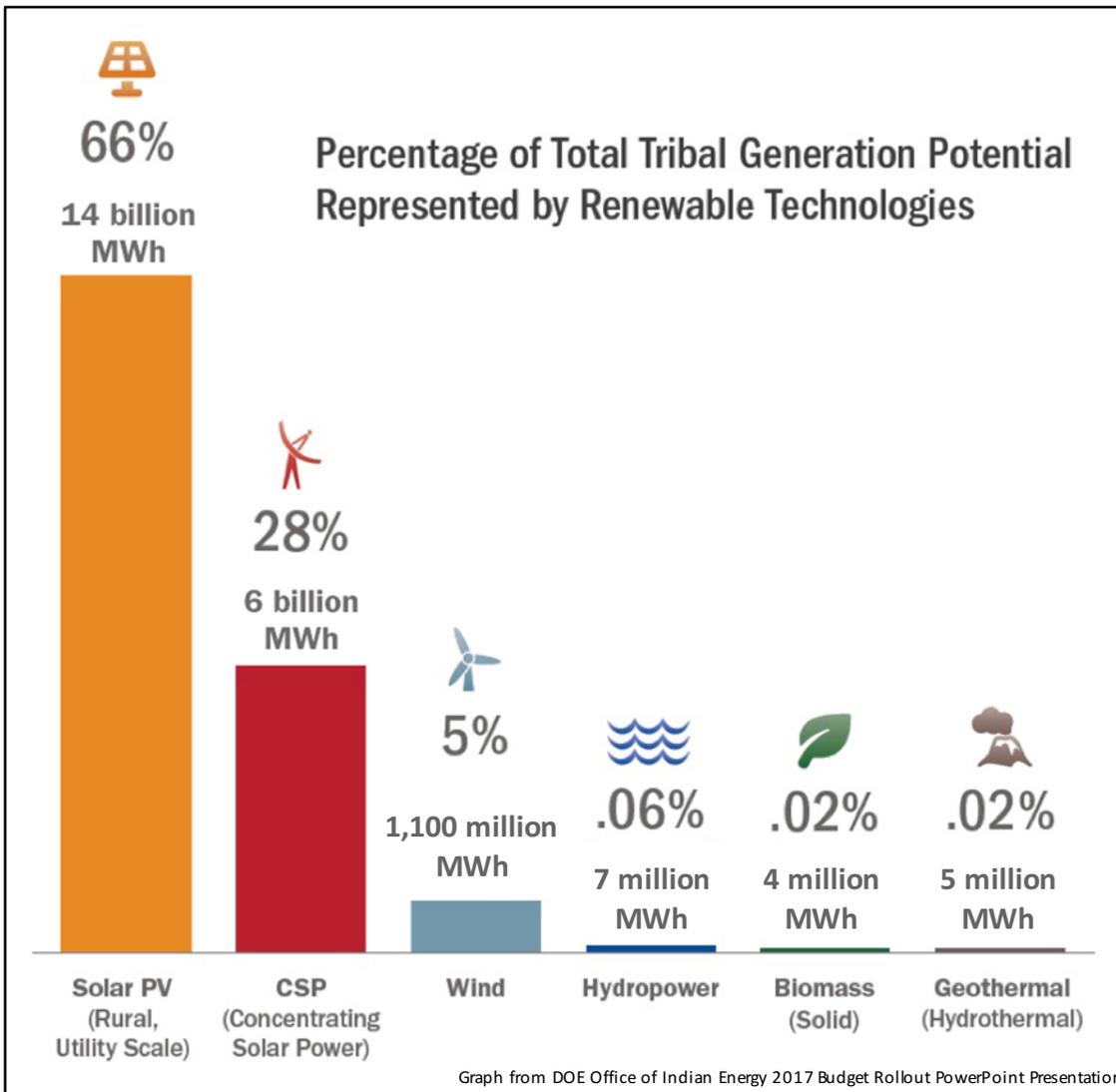
About me



South Dakota School of Mines & Technology
Majors: MS Civil & Environmental Engineering
MS Engineering Management
May 2017
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Background



- American Indian lands comprises ~2% of US and contains ~5% of all renewable energy resources.
- Total technical potential on tribal lands ~21 billion MWh.
- Waste as renewable vs. waste conservation?

Waste to Energy

- Generating energy in the form of electricity and/or heat from the incineration of waste.
- Processes: Thermal & Non-thermal
- Thermal:
 - Depolymerization
 - Gasification
 - Pyrolysis
 - Plasma arc gasification
- Non-thermal:
 - Anaerobic digestion

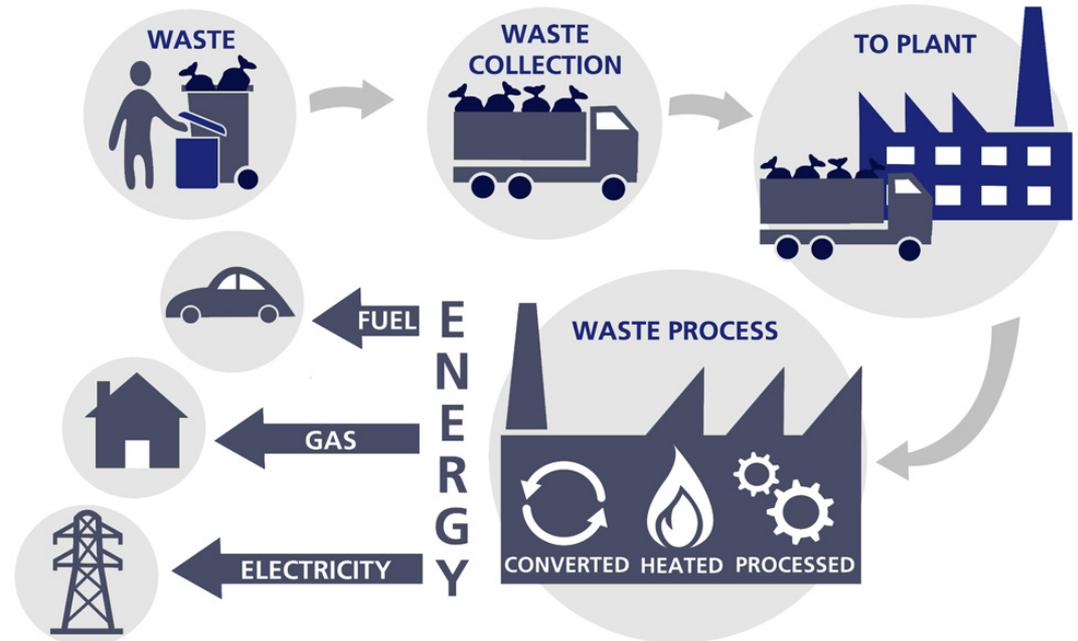
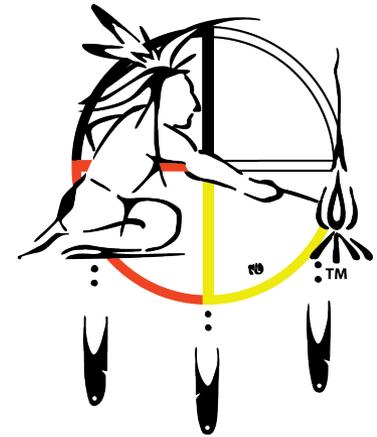


Figure from Global Re-Energy Website: www.globalre-energy.com/about-waste-to-energy-facilities/

Forest County Potawatomi Community

- A 2 MW anaerobic digester and biogas generation facility.
 - converts food waste into electricity power 1,500 homes
- Long-term energy goal to reduce its carbon footprint to zero.
 - Assumed a leadership role in creating a sustainable and healthy world
 - 2014: Ranked among the Top 100 and Top 30 Local Government green power users



**FOREST COUNTY
POTAWATOMI**
Keeper of the Fire

Microbial Fuel Cell (MFC) Technology

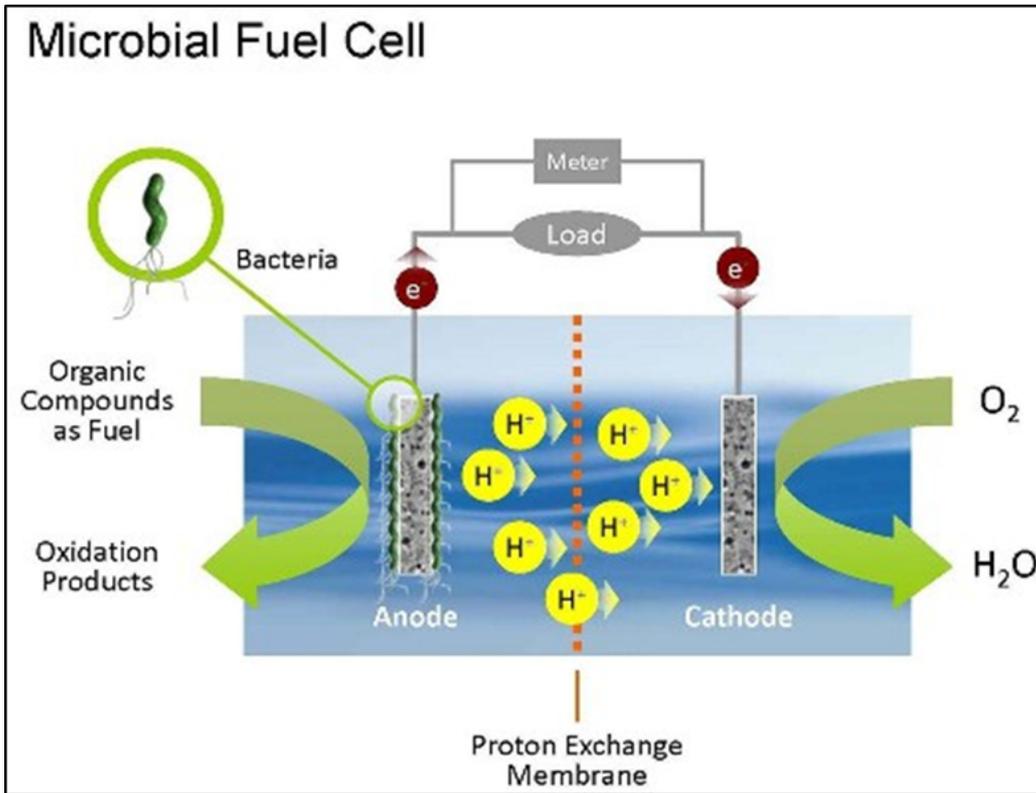
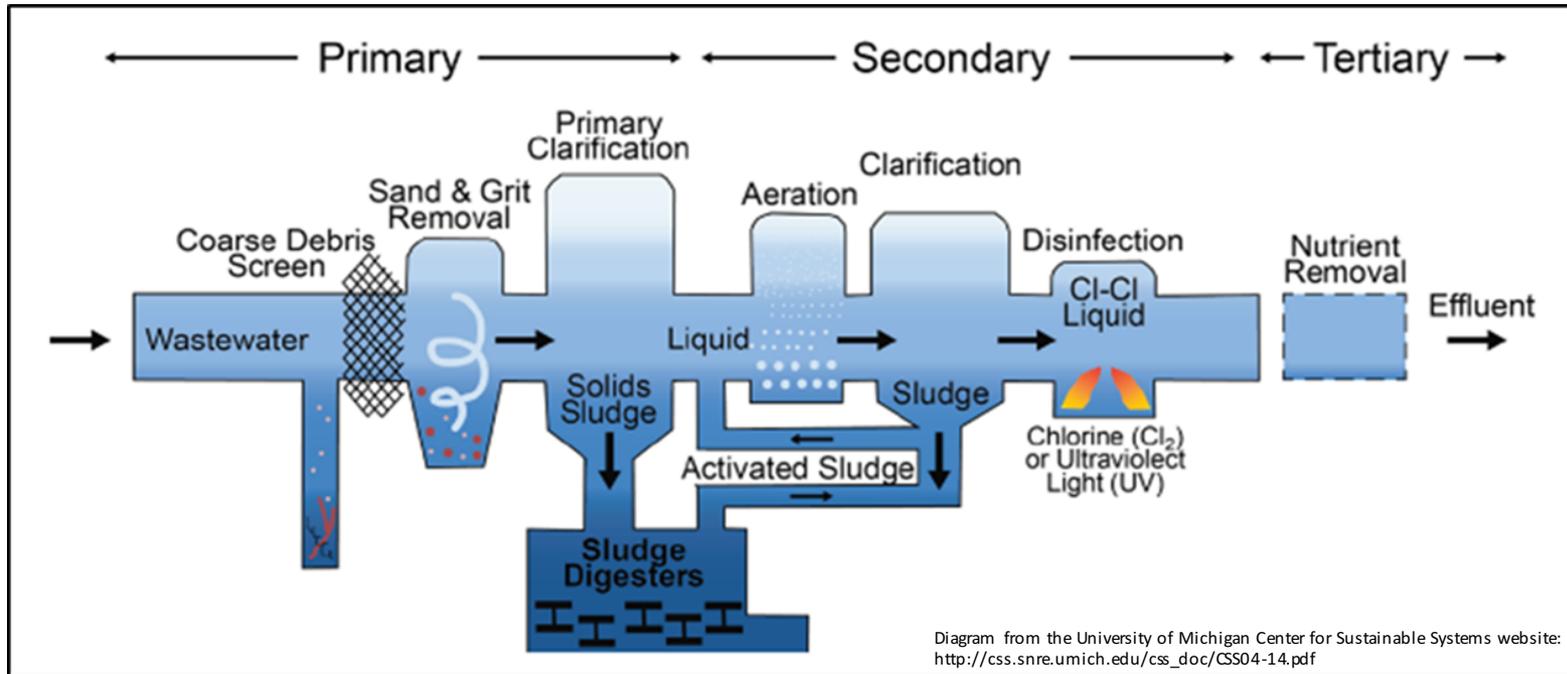


Diagram from Avanti Corporation website: <http://www.avanticorporation.com/green-remediation/>

- MFCs require “fuel.”
 - Organic waste, food waste, wastewater
 - MFCs are fed with the wastewater containing both the fuel and the bacteria responsible for its degradation.
 - MFC bacteria will oxidize the fuel and use the anode as an external electron acceptor.
 - Electrical power is generated by the electrons flowing from the anode through an electrical circuit to the cathode, where the reduction of an electron acceptor (oxygen) occurs.
 - At the cathode, the protons and electrons combine with oxygen to create water.
- Four parts: anode, cathode, proton exchange membrane (PEM), external circuit

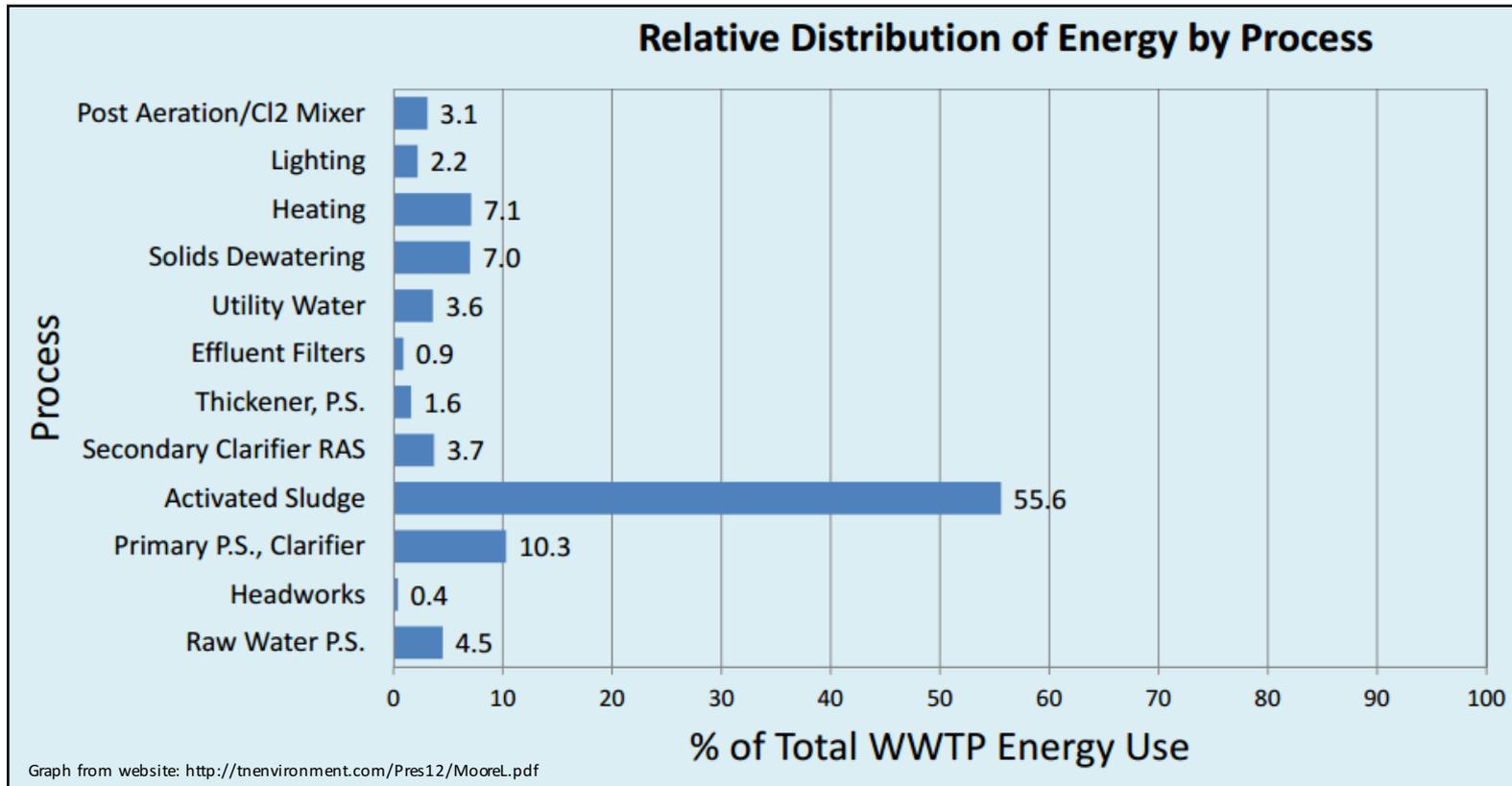
Wastewater Treatment

- Types of treatment:
 - Physical, Biological and Chemical



- Energy consumption:
 - ~3% of total U.S. electricity consumption
- Treating and pumping of water requires substantial amounts of power
 - ~80% of total energy used is from transportation of water

Relative Energy Distribution of Wastewater Treatment Processes



- Based on secondary wastewater treatment plant (7 MGD)

Potential Benefits and Practical Challenges

Benefits:

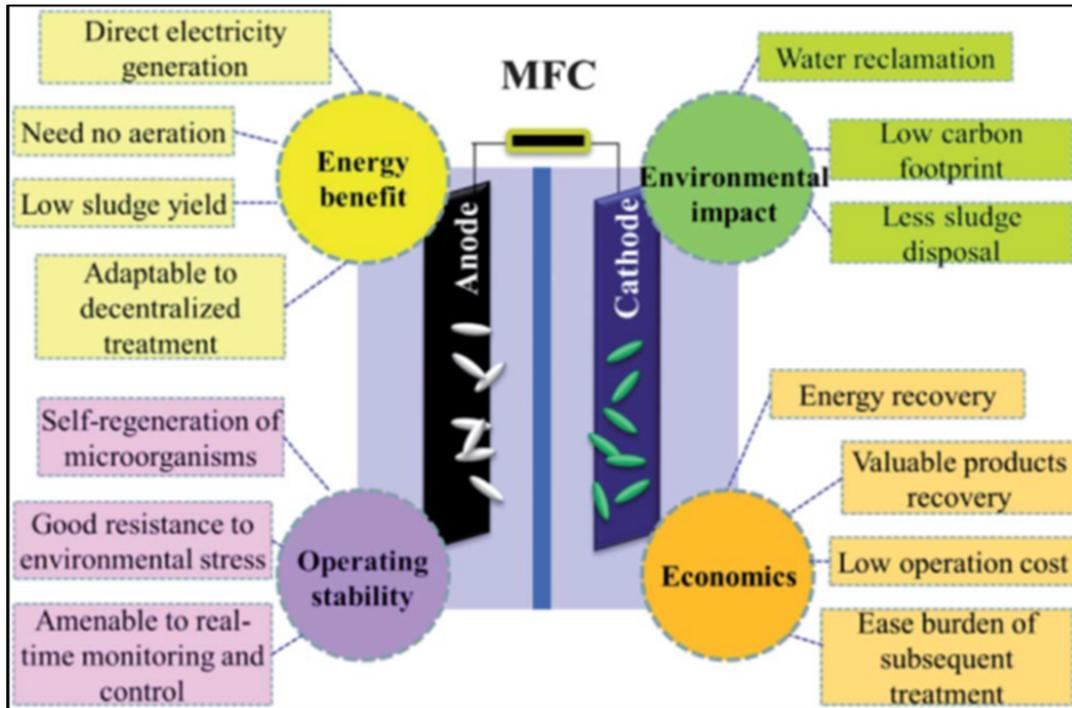
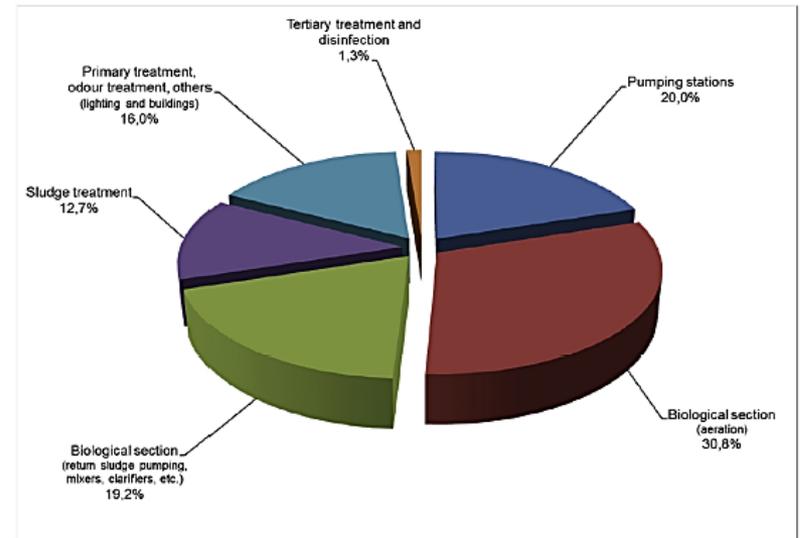
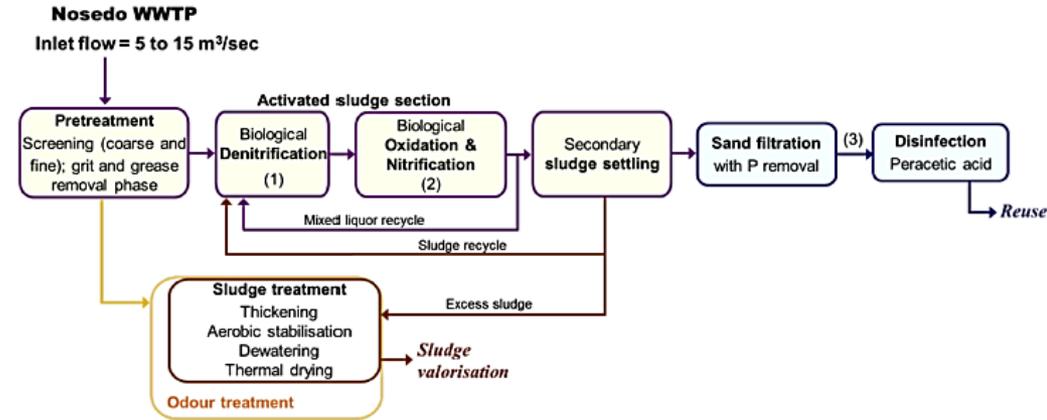
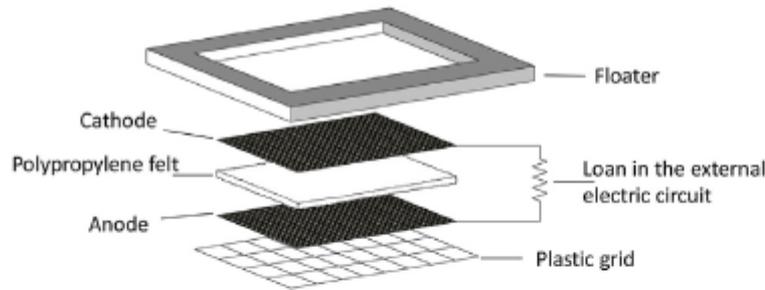
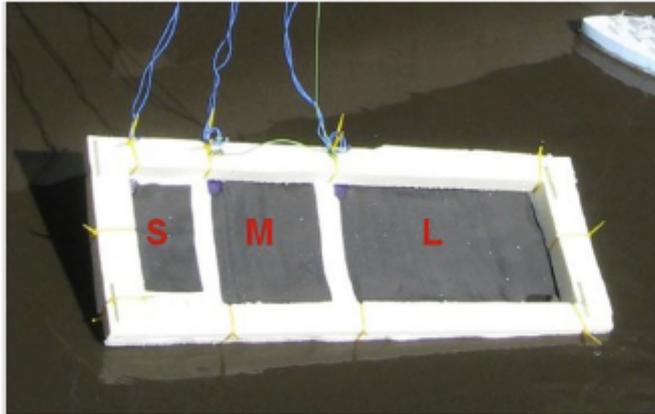


Figure from "Towards sustainable wastewater treatment by using microbial fuel cells-centered technologies" article by W.Li.

Challenges:

- Initial capital investment, operation and maintenance expenses associated with energy, chemicals and materials consumption, and deteriorated performance during long-term operation
- Scaling up an MFC system for real world application
- Weak current generation when singular

Example: Completed Case Study for Milan-Nosedo Wastewater Treatment Plant



Figures from Energy balance and microbial fuel cells experimentation at wastewater treatment plant Milano-Nosedo article by E. Martinucci.

- Variable output; smallest MFCs showed better performances
- Limit of scaling up MFCs suitable for stack system and to improve the produced power.

Example: Prototype Completed by Penn State Research Team

- Proof of concept device that can generate 0.9 kWh of electricity per kg of organic waste.
 - Plants that consume, on average, 1.2kWh per kg of waste, can produce a positive amount of current while continuing to perform their conventional function.
- Device combines an MFC with a reverse electro dialysis system—which separates ions in a series of membranes.
- MFC's in the proof of concept also act as a final cleaning stage in the wastewater treatment process.
- Organic matter treated much faster.



Why Microbial Fuel Cells (MFCs)?

- Waste to energy technology
- MFCs use bacteria to convert organic matter (fuel) directly into electricity.
 - Reduction/elimination of methane produced/transported
- Reduction of sludge and removal of aeration process.
 - Reduction of energy consumption and solid waste removal
- Organic matter treated quicker.
- Emerging technology with potential for positive impact and technological advancements.
- Application of MFCs to tribal application.
 - Managing wastewater to potentially use as a form of energy.

Future Work

- Collection of data on wastewater treatment infrastructure on tribal lands.
 - Collection of data for energy consumption on tribal lands.
- Determine MFC potential on tribal lands using wastewater as a renewable resource
 - Determine quantity of municipal wastewater
 - Quantifying the amount of Gibbs free energy available in the waste compound in order to estimate the electric power than can be generated.



Pilamaye Tanka!

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- Sandra Begay
- Fellow Indian Energy Interns:
 - Len Necefer, Tommy Jones, Rachael Gutierrez
- SDSM&T Faculty:
 - Dr. Jennifer Benning, Dr. V. Gadhamshetty



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