**Bio-electrochemical technologies for solving food-water-energy nexus challenges in upper great plain region- A case study on efficient wastewater reuse**

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### Introduction to Upper Great Plain Region:
- Upper great plain region (UGP) includes the regions of South Dakota, Iowa, Montana, Nebraska, and North Dakota.
- UGP is a major exporter of food and energy and utilizing significant volumes of water and nutrient.
- Food production, and water and energy consumption are interdependent processes. For instance, conversion of grassland reduces ground water resources.
- The food-water-energy nexus in the UGP is currently influenced by the Bakken shale-oil boom, corn-ethanol production, coal mining, wind farms, and hydroelectric dams.
- It is important to balance the economics, technological innovation, and culture to sustain food-water-energy nexus in UGP.

### Bakken Shale-oil Boom:
- Subsurface of the Williston Basin, underlying parts of Montana, North Dakota, Saskatchewan, and Manitoba.
- Bakken oil production increased from 150 thousand bbl/day in 2007 to 1350 thousand bbl/day in 2015.
- Hydraulic fracturing and horizontal drilling is used for oil extraction from impermeable formations. This process generates significant amount of produced and flowback water.
- Flowback waters is characterized with high total dissolved solids (~200,000 mg/L) and chemical oxygen demand (1200 mg/L).

### Problem statement:
- Existing technology for backflow water treatment like thermal or membrane processes coupled with pretreatment is prone to fouling, also expensive and energy consuming.

### Approach:
- A two-stage treatment for backflow water based on electrochemical processes followed by biological treatment for Bakken’s backflow water.

### Bio-electrochemical technologies (BETs):
- The BETs uses specialized microbes called as anaerobic respiring bacteria (ARB).
- The ARBs can be used for simultaneous wastewater treatment, desalination, and electricity production.
- Examples of BETs are microbial fuel cells (MFCs), microbial electrolysis cells (MECs), and microbial desalination cells (MDCs).

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### A Case Study of Bio-electrochemical Technologies for Wastewater Reuse in Powerplant:

#### Water Energy Nexus:
- Power plants in the US consume ~40% of total freshwater withdrawals.
- Wastewater Treatment:
  - Energy: ~0.5-2.0 kWh/m3
  - Sludge Disposal: ~60% of total operating cost
- Energy-intensive wastewater treatment plants annually spends 4480 MW to treat wastewater.

#### Goals:
- Evaluate the municipal wastewater as the electron donor in the anode of MFCs.
- Examine the viability of MFCs/membranes to enable wastewater reuse (power plants).

### Methodology:

#### Measurement Analysis:
- **pH**: pH meter.
- **Conductivity**:
  - **Conductivity Demand - Using spectrophotometer based on standard methods**.
  - **Ion measurement**:
    - Using atomic absorption spectrometer based on Standard methods.
- **Cyclic Voltametry**: Using Potentiostat.
- **Electrochemical Impedance analysis**: Using Potentiostat.

#### Results:
- **Chemical Oxygen Demand (COD) Removal**:
  - We achieved 90% COD removal in the Rapid City’s wastewater.

#### Summary:
- **Electrochemical Impedance**:
  - High impedance in wastewater (~6.7 kΩ cm²) than in acetate (~0.28 kΩ cm²).
  - Power production using wastewater (325 mW/m²) less than acetate (150 mW/m²).

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### Experimental Plan:

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<tr>
<th></th>
<th>Electron Donor</th>
<th>Electron Acceptor</th>
<th>Media</th>
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<tbody>
<tr>
<td>MFC1</td>
<td>Bakken Backflow water</td>
<td>Oxygen</td>
<td>100 mM</td>
</tr>
<tr>
<td>Control1</td>
<td>Artificial Salt water</td>
<td>Oxygen</td>
<td>100 mM</td>
</tr>
<tr>
<td>Control2</td>
<td>None</td>
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