Introduction/Motivations/Objectives/Context

- Wastewater in the UK
- How bad is it and evidence
- Establish clear problem
- Bring up MFCs
- Description and discussion of major design parameters
  - A table could be a coherent way show them
- Can use diagram from Zheng and Halme 1995 for visualisation

Aims

- Assess currently available literature on MFCs
- Present a clear and logical narrative
- High quality critical analysis
- Set the project within a wider context

The Plan

- Literature read in preparation for dissertation
- Covers a range of key topics
  - Background and context:
    - Expand my knowledge
    - Provide information for the reader
      - Strike a balance between this analysis and the critical review
  - Review papers:
    - What is the current situation in the research community
    - Work that has been done
    - Suggested areas of future work
  - Experimental work:
    - Detailed information on current capabilities
    - Results that can be used for comparison to test model viability
    - Helps define what our models should be looking for
  - Modelling Papers
    - Specific work relevant to my project
    - What are the assumptions and why?
    - Parameters that were considered and why?

Background

Microbial fuel cells

Logan (2008) - Most of the information I've learned from this will go in the beginning - Key parameters, general design etc - Proposes how an MFC based Wastewater Treatment Plant would function - Evidence for intro/motivations of research - Approximately 200 mg L^{-1} of organic matter in fluid - Possible value for model parameter - Concept of normalising power by surface area and volume - A way to assess performance of model and provide comparison - Highest is 0.115 kW m^3 - Minimise Rint - Energy efficiency ranges from 2%-50%

Review

Developments in microbial fuel cell modelling

- "Interest has significantly increased in recent decades"

- MFC modelling tends to be neglected
- Introduces the comprehensive type of models
- Anode based
- Cathode based
- Mentioned parameters that are important:
  - Biofilm thickness
  - Fuel flow rate and concentration
  - Temperature (mentions experimental ranging from 15-40 degrees C)

Models for Microbial Fuel Cells: A critical review

- Different models make different assumptions:
  - Full vs half cell models
  - Mechanism vs Application based
    - Mechanism: Focus on key reaction processes: substrate utilisation, voltage and current, biofilm formation etc
    - Application: Focus on electrical models to aide understanding of how MFCs will function as electrical devices
  - Mine will be mechanism based
- Doesn't mention models that considered temperature as their primary parameter
- Therefore my research has a USP

Experimental Work

Power generation from wastewater using single chamber microbial fuel cells (MFCs) with platinum-free cathodes and pre-colonized anodes

- Operated for 26 weeks
- We don't want biofilm growth on cathode due to increased proton transfer resistance
- Colonized with wastewater - University of Connecticut wastewater treatment plant
  - Potential flow basis for my model
- Operated at 30 degrees

Continuous electricity production from artificial wastewater using a mediator-less microbial fuel cell

- Mediator is used to separate out cathodic and anodic fluids
- Anode volume of 20 ml
  - scale-up issues
- Best result obtained at 35 degrees
  - Not realistic for UK expect for heatwaves
- Power stably generated over 2 years
  - Viability for larger scale deployment if individual cells don't require frequent maintenance

Electricity generation of single-chamber microbial fuel cells at low temperatures

- Main source of comparison with my model at present
- 4-30 degrees C
- States that initially operating MFCs at 30 degrees allows them to provide reasonable power generation at lower temperatures
- Evidence for feasibility of project

Modelling

A 1D mathematical model for a microbial fuel cell

- Model correctly predicted how substrate concentration and temperature affect biofilm thickness and cell performance
  - Therefore project is feasible
- Modelled temp ranges of 20,30 and 40 degrees
  - Varying temperature is a possibility of these models
- Since lower temperatures not considered, research maintains a niche

A two-population bio-electrochemical model of a microbial fuel cell

- "Energy from organic waste cannot be recovered using traditional methods"
- This is because it has a complex composition and is usually very dilute
- Model based on anode and focuses on bio-chemical reactions there
  - Therefore, assumes cathode reaction rate is non-limiting
- Demonstrates influence of organic load and external resistance on the MFC power output and long term performance
  - Experiments from 35 - 60 days
  - Adjusted influent acetate concentration between 275 - 2550 mg-S L-1
  - External resistance set between ~10-25 ohms above Rint as well as 5 ohms (below Rint)
- Validated with experimental results
  - Plots of simulated vs measured results show the models follows the patterns of behavior of MFCs
  - Results look pretty good based off graphical comparisons

Modelling and simulation of two-chamber microbial fuel cell

- "Modelling remain scarce"
- Claims cathodic reaction is the rate limiting step
- Flow has an effect on power
- Artificial wastewater
- Useful for scale-up
- Claims reducing feed flow could increase power

A generalized whole-cell model for wastewater-fed microbial fuel cells

- Mentions a lit review that found COD removal efficiency can be between 5-99% depending on operating conditions.
- Experimental work featured municipal wastewater
- Whole cell model so anode and cathode
- Model assesses after the startup phase of 32 days

Electricity generation and modelling of microbial fuel cell from continuous beer brewery wastewater

- COD removal efficiency of 40-43% classed as good enough for wastewater treatment
- Low flow-rates considered in experimental work
- Most detailed wastewater description
- Cell operated between 20-28 degrees C

Logan, Bruce E. 2008. Microbial Fuel Cells. Book. Hoboken, N.J: Wiley-Interscience. https://doi.org/10.1002/9780470258590.