

# Evaluation of industrial wastewater properties and microbial diversity to improve power generation in Microbial Fuel Cells

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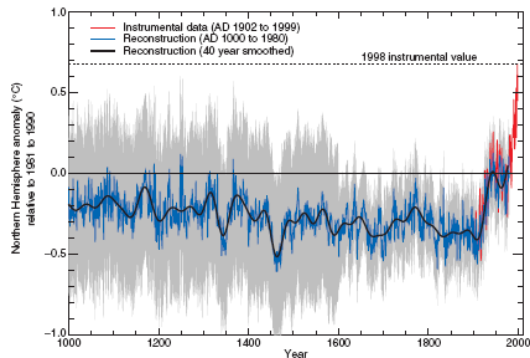
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# Introduction

## Environmental Issues

- Global Warming



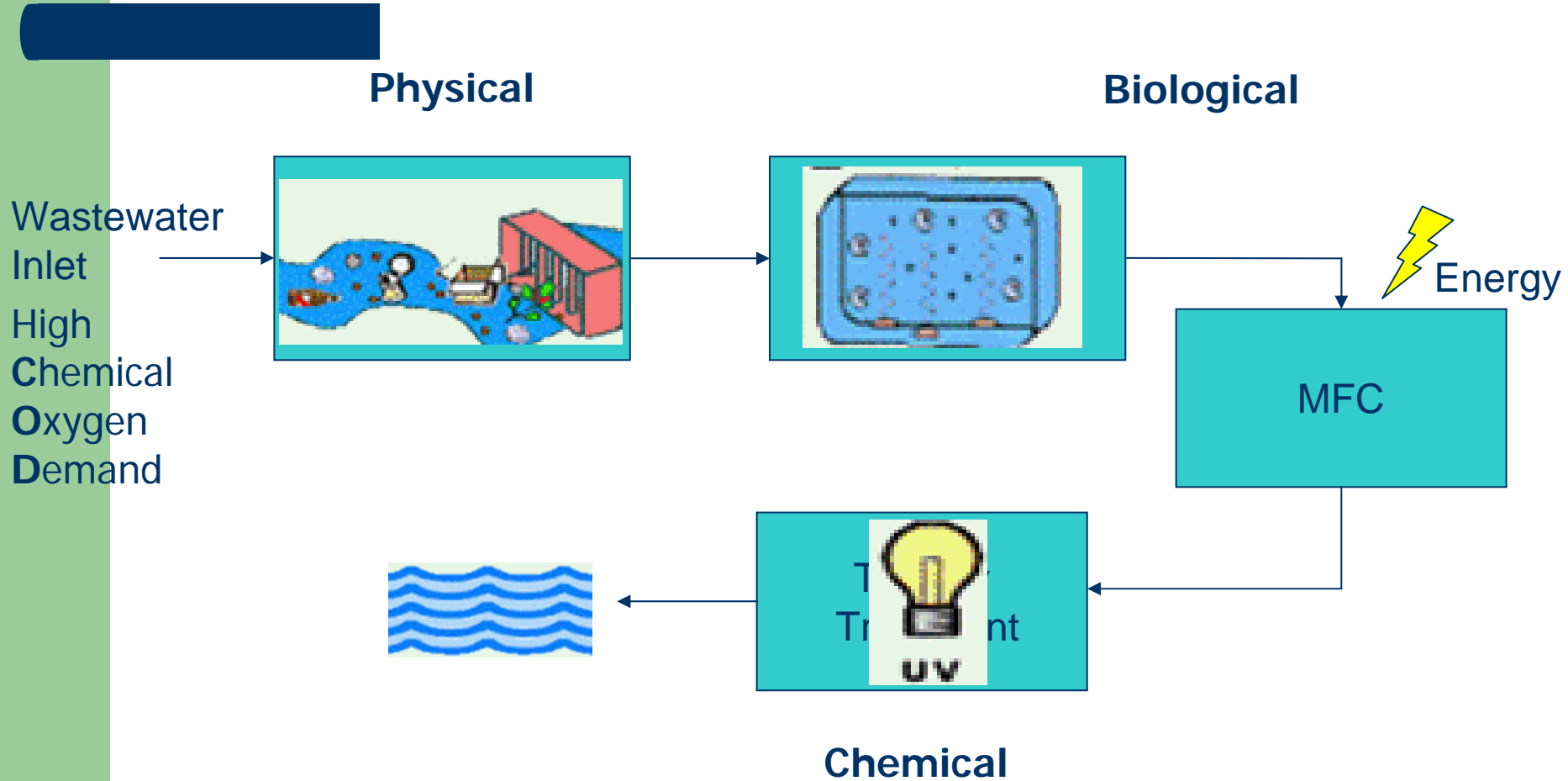
- Wastewater discharges



## Cost Pressures

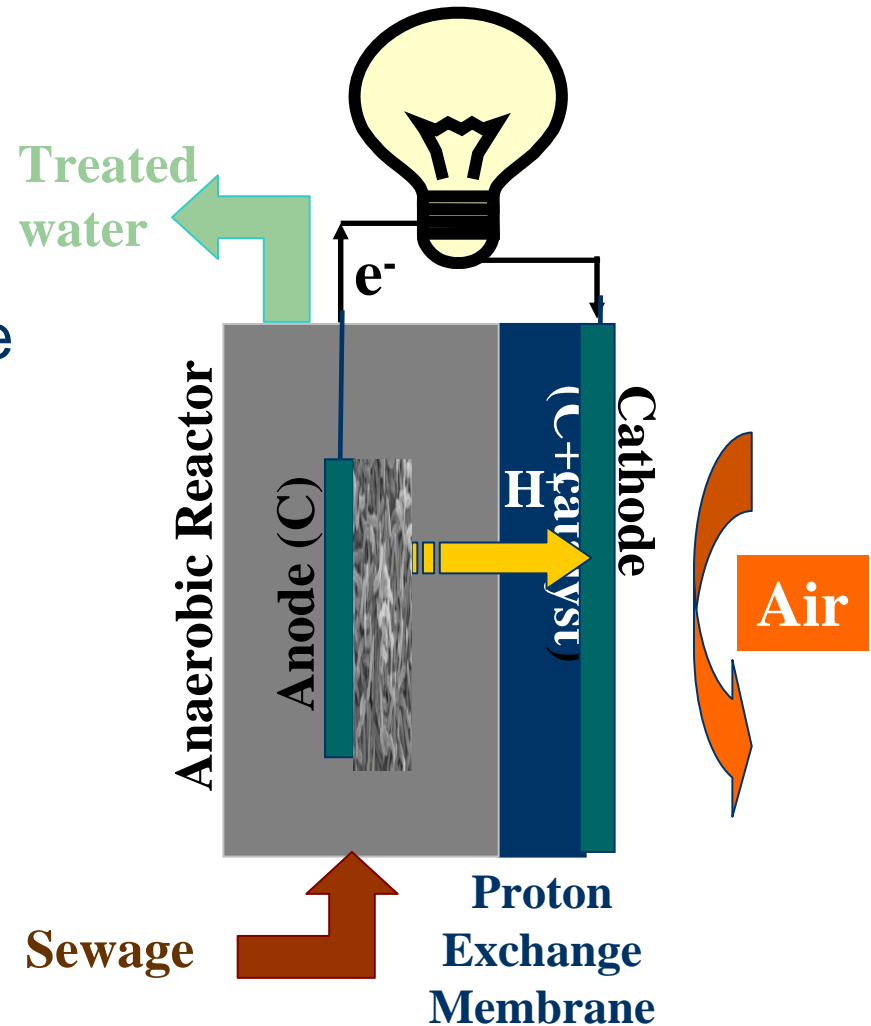
- UK energy costs will come under great pressures due to increased import
- Carbon emissions are going to carry an increasing price tag
- Customers are going to pick suppliers that focus on sustainability

# Wastewater Treatment Systems



# How do Microbial Fuel Cells (MFC) work?

Inside an MFC lives a colony of bacteria under anaerobic conditions. These bacteria are fed sewage which they oxidize to create a flow of current. MFCs consist of an anode and cathode similar to a conventional battery.

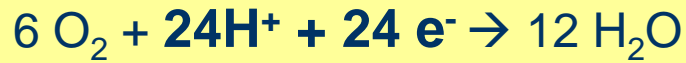


# Mechanism

CO<sub>2</sub>



Protons

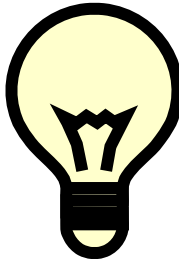


Water

*Mediators or  
direct contact*

Electrons → Electrode (Anode)

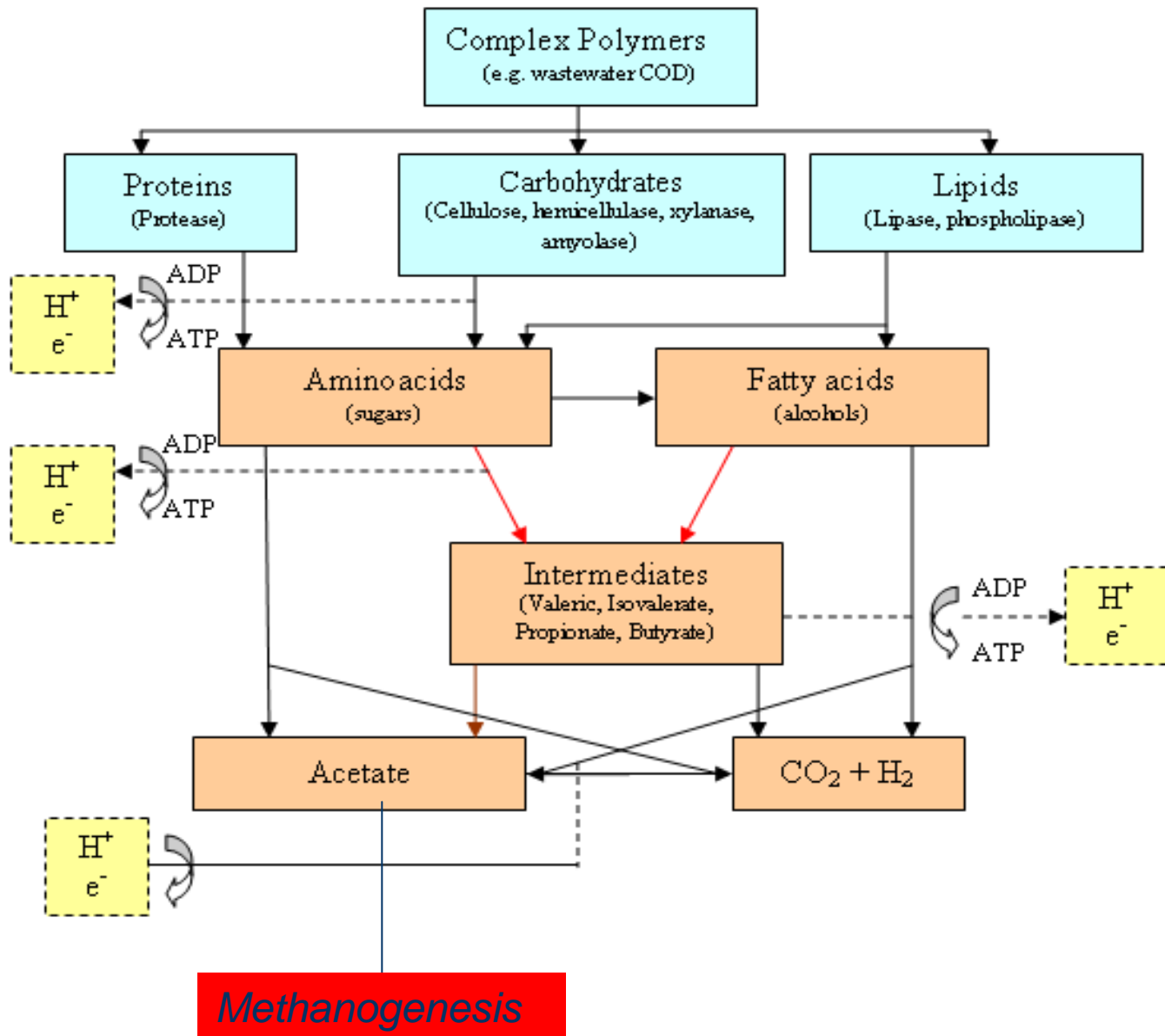
↓  
Electrical Circuit



← Electrons ← Electrode (Cathode)

Hydrolysis

Electron flow

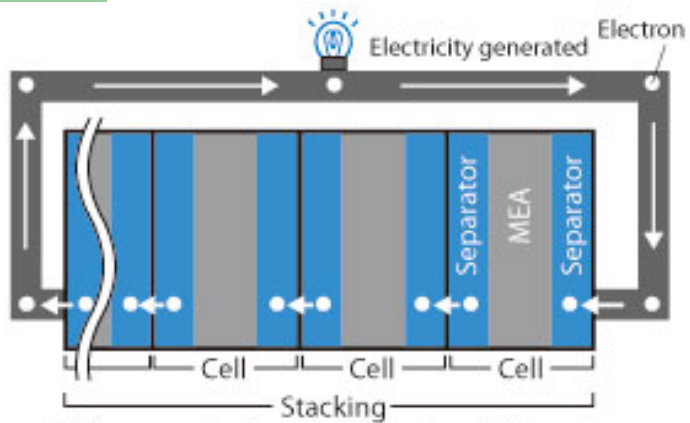


# Differences with Anaerobic WT

- Conventional
    - Hydrolysis
    - Fermentation
    - Methanogenesis
  - Methane and CO<sub>2</sub> production
  - Biogas production to be processed for electricity generation
  - T > 20°C
- Microbial Fuel Cells
    - Hydrolysis
    - Fermentation
    - Shuttle of electrons
  - Lower quantities of Methane production
  - Electricity generation directly from anaerobic processes
  - T < 20°C



# Designs



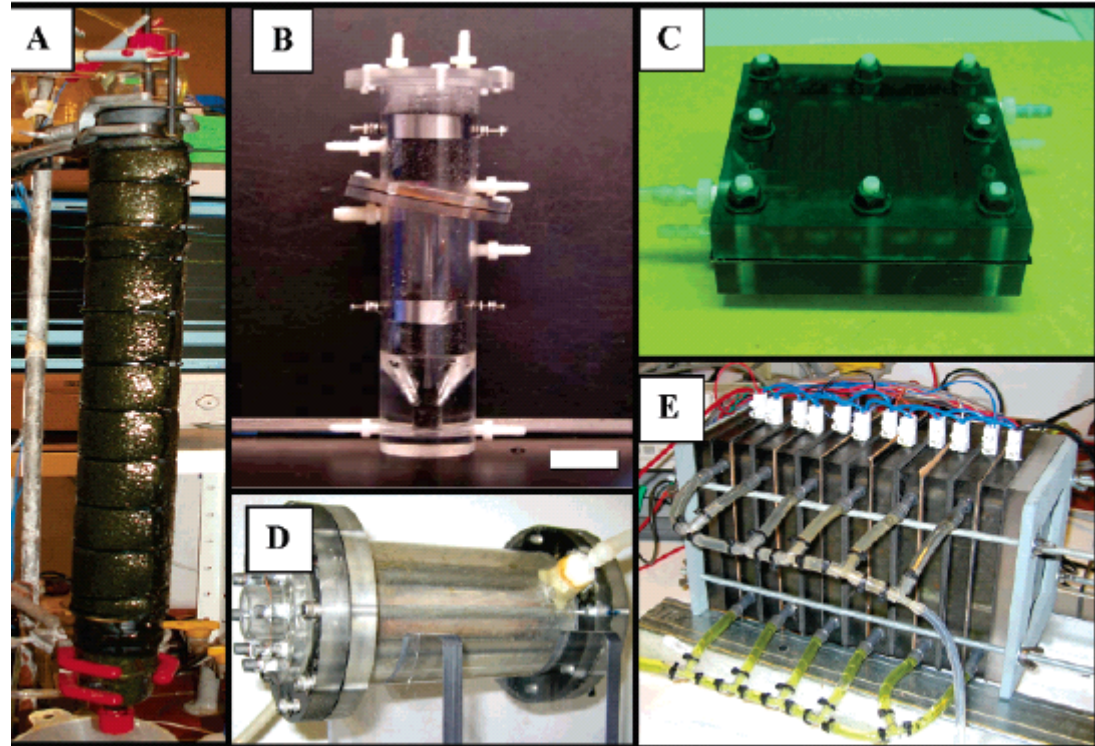
Cells are stacked in series, like dry-cell batteries

Voltage: Determined by number of layers;  
unrelated to surface area of electrodes

Current: Determined by surface area of electrodes;  
unrelated to number of layers

$$\text{Voltage} \times \text{Current} = \text{Output}$$

To increase output: { Increase number of layers  
Increase surface area of electrodes. }



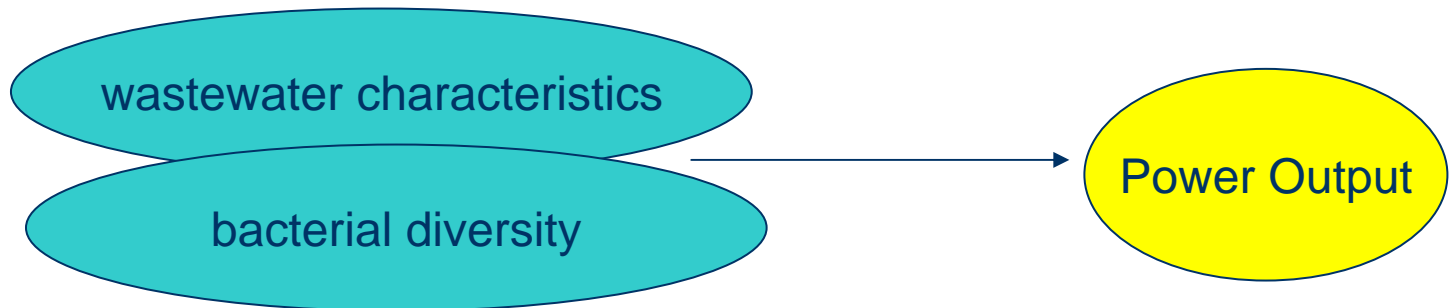
# Substrate effect in MFC

- Wastewaters: domestic, food processing, swine wastewater and beer processing (*Du et al, 2007*).
- Wastewater characteristics affect:
  - rate of organic matter degradability
  - microbial ecosystem
    - rate of bacterial electron transfer
    - overall MFC process efficiency
- Why study wastewater characteristics?
  - To increase the understanding of the mechanisms affecting electron shuttling rates
  - To explore for alternatives for MFC control and optimization according to the type of wastewater used

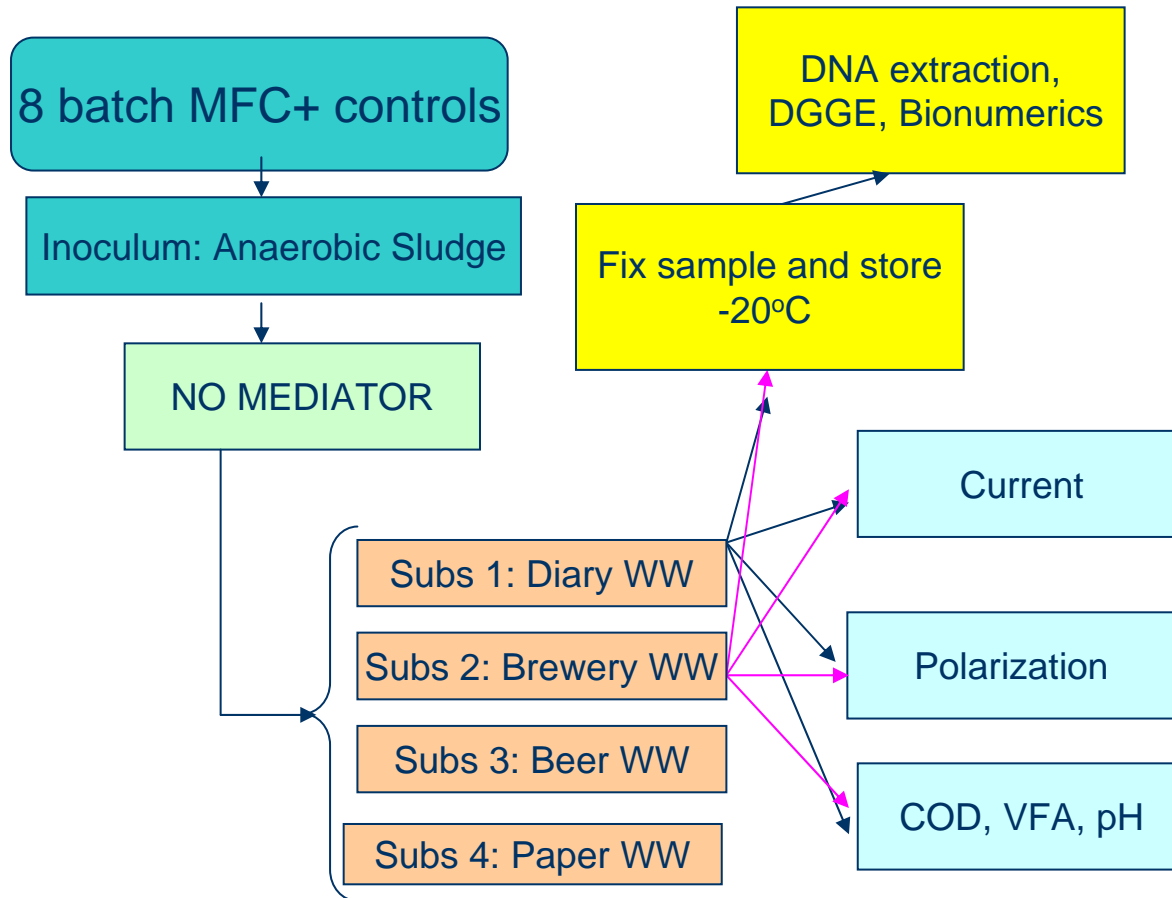
# Aim and Objectives

“To study the substrate effect in MFC”

- To compare the effect of using different industrial wastewaters in bioelectricity generation :Bakery, brewery, paper and dairy
- To determine the relationship between:



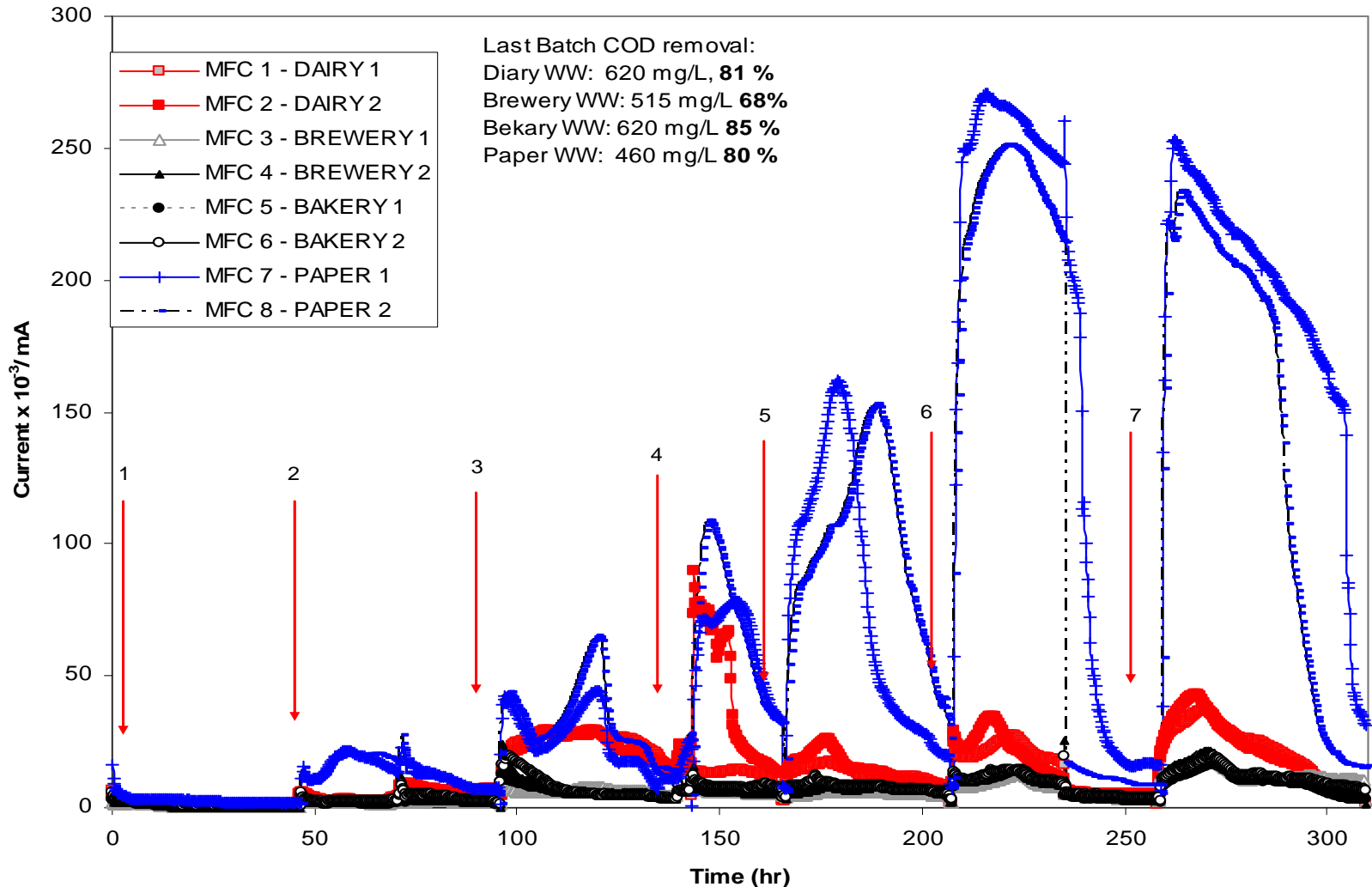
# Methodology



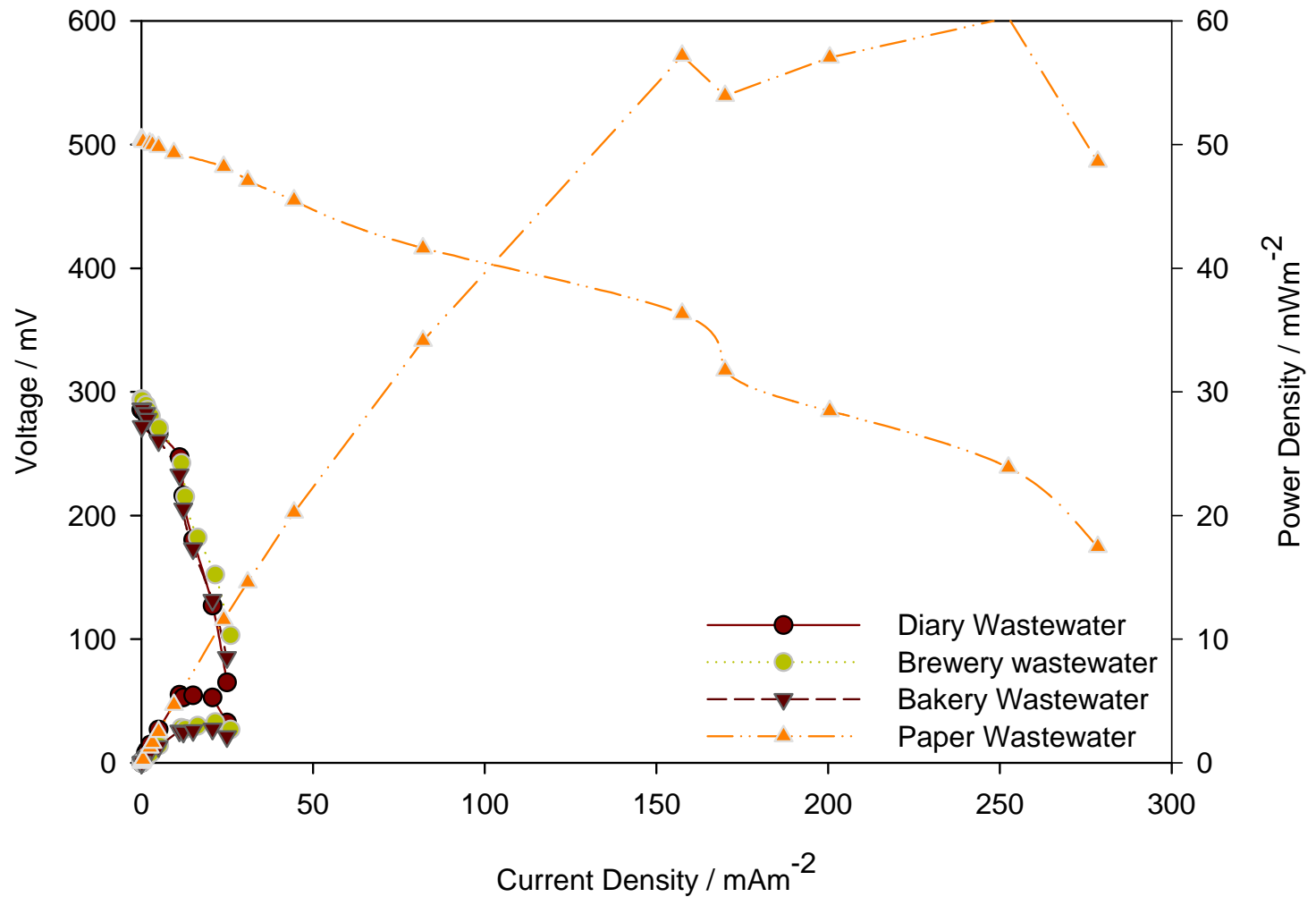
# Methodology: Wastewaters Characteristics

Wastewater	Dilution (in tap water)	COD <sub>s</sub> (mg/L)	Anions (ppm)	pH (NaCl or HCl)	Conductivity μS/cm
<b>Diary WW</b>	50/200	700	Fluoride: 0 Chloride: 138 Phosphate: 6 Sulphate: 31	7	832
<b>Bakery WW</b>	13/200	651	Fluoride: 12 Chloride: 11 Phosphate: 6 Sulphate: 8	7	79.6
<b>Brewery WW</b>	1.3/200	661	Fluoride: 1.3 Chloride: 5 Phosphate: 3 Sulphate: 10	7	180.6
<b>Paper WW</b>	200/200	600	Fluoride: Chloride: 189 Phosphate: <b>Sulphate: 241.3</b>	7	1397

# Results: current production

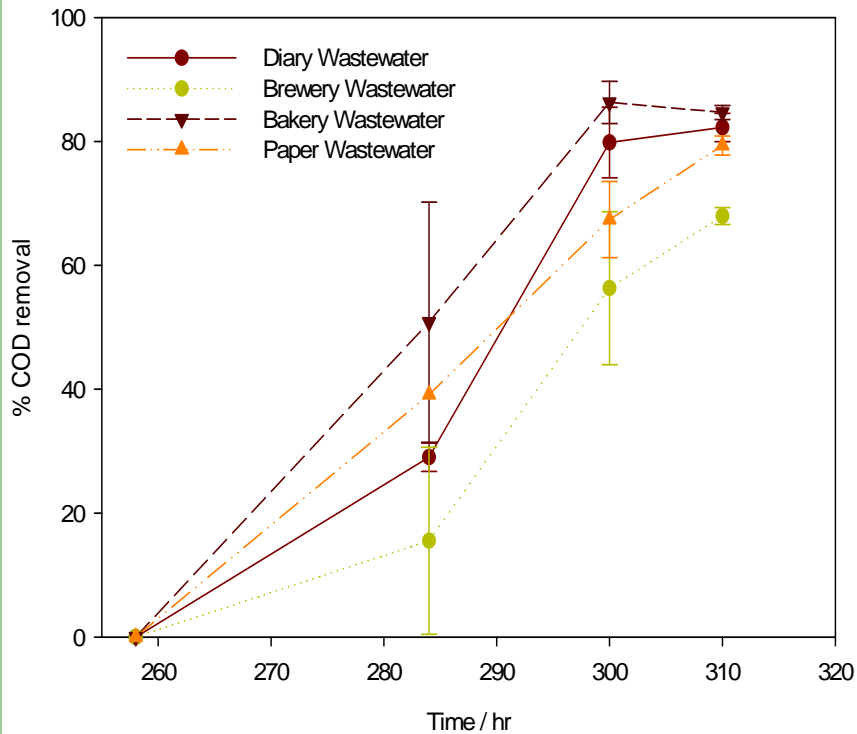


# Results: polarization

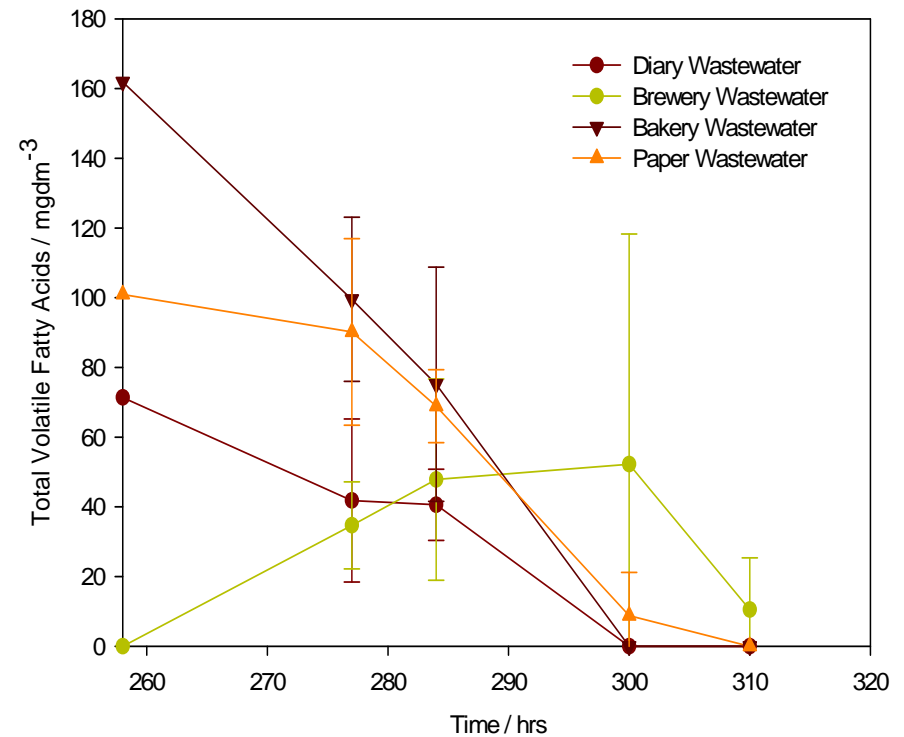


# Results: process parameters

## COD removal



## VFA concentrations



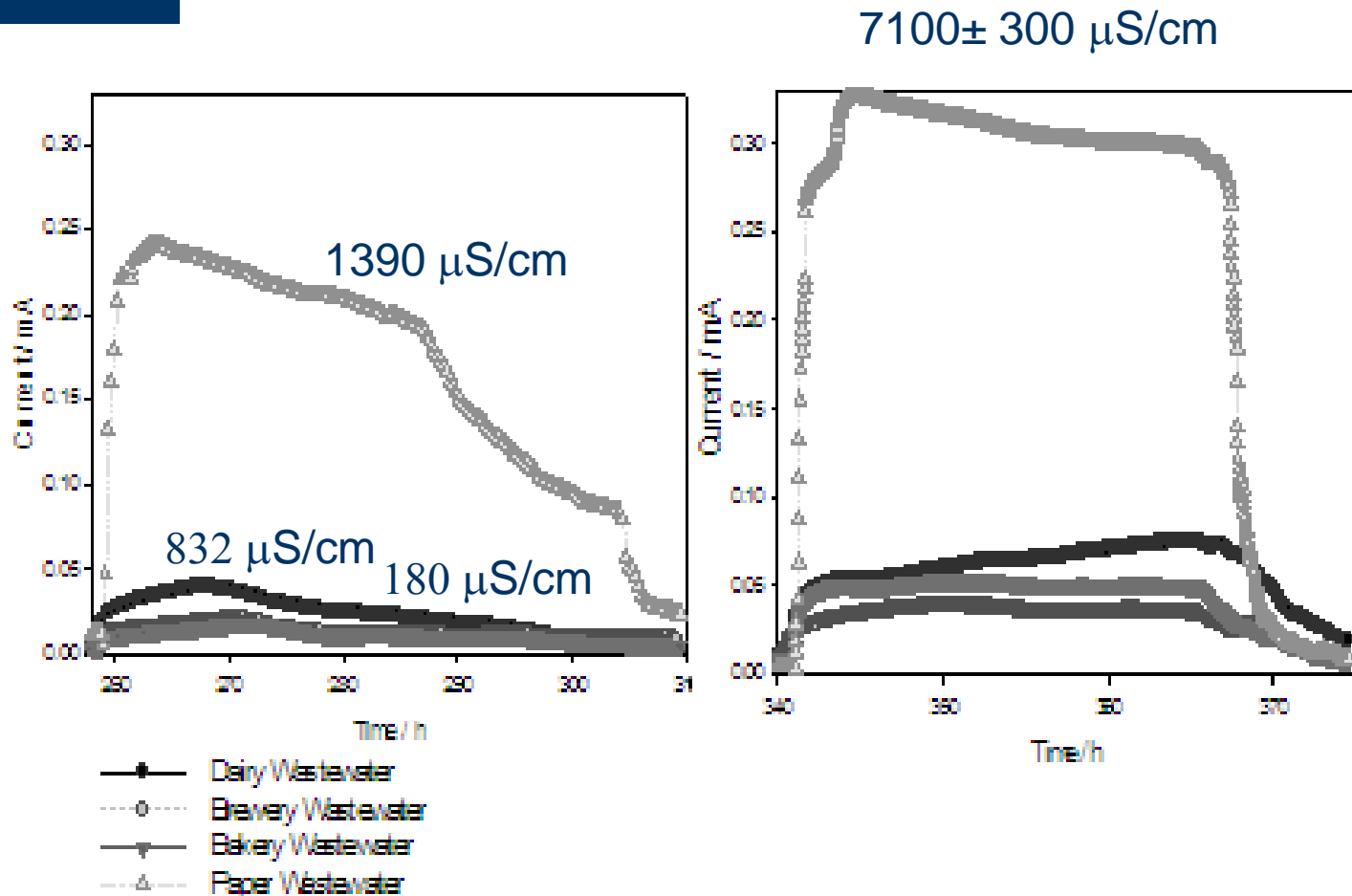


# Why some WW are not producing electricity?

Electrochemical processes are being favoured in the reactor containing paper wastewater

1. Effect of different conductivities
2. Effect of different types and quantities of bacteria
3. Effect of electron shuttle mediators

# 1. Results: conductivity



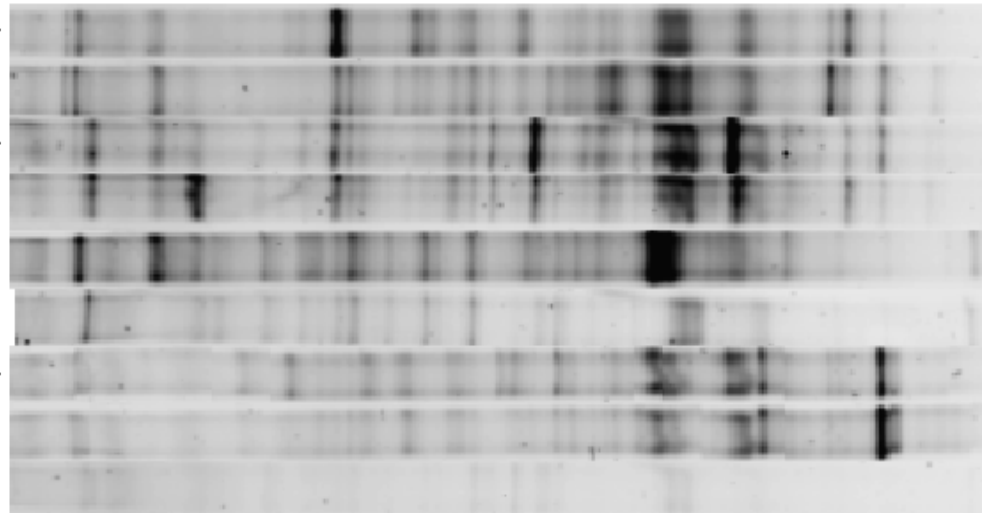
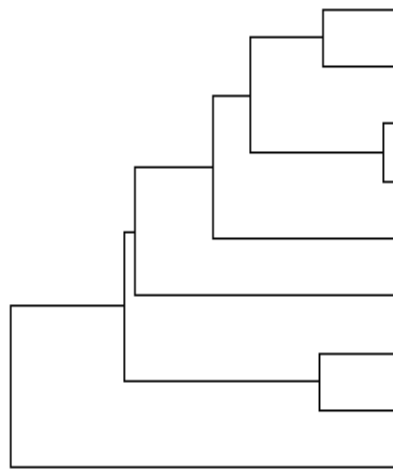
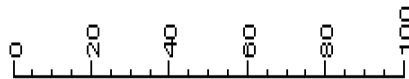
# 2. Results: bacteria



Dice (Tol 1.0%-1.0%)(H>0.0% S>0.0%) [0.0%-100.0%]

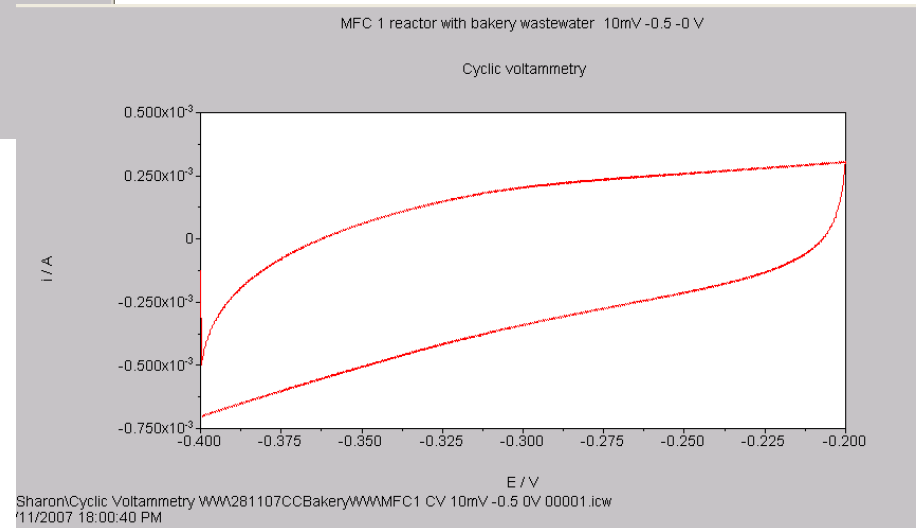
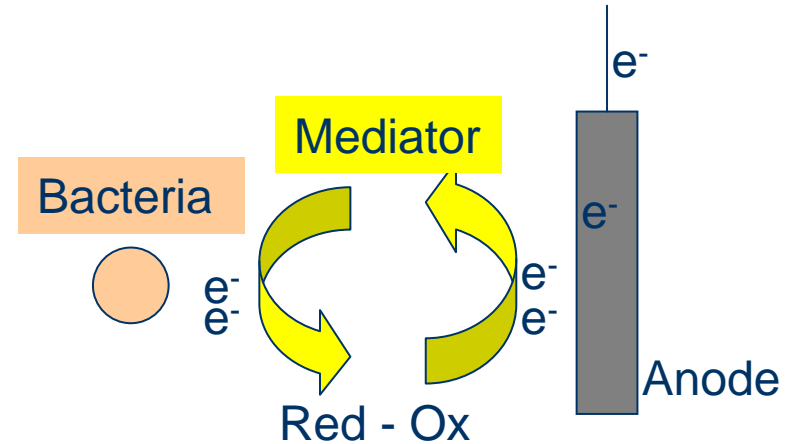
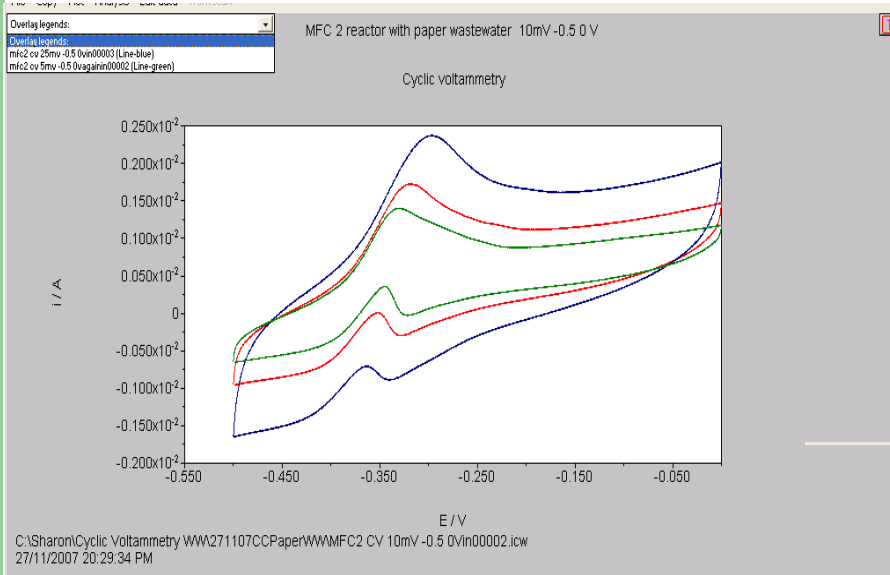
DGGE

DGGE



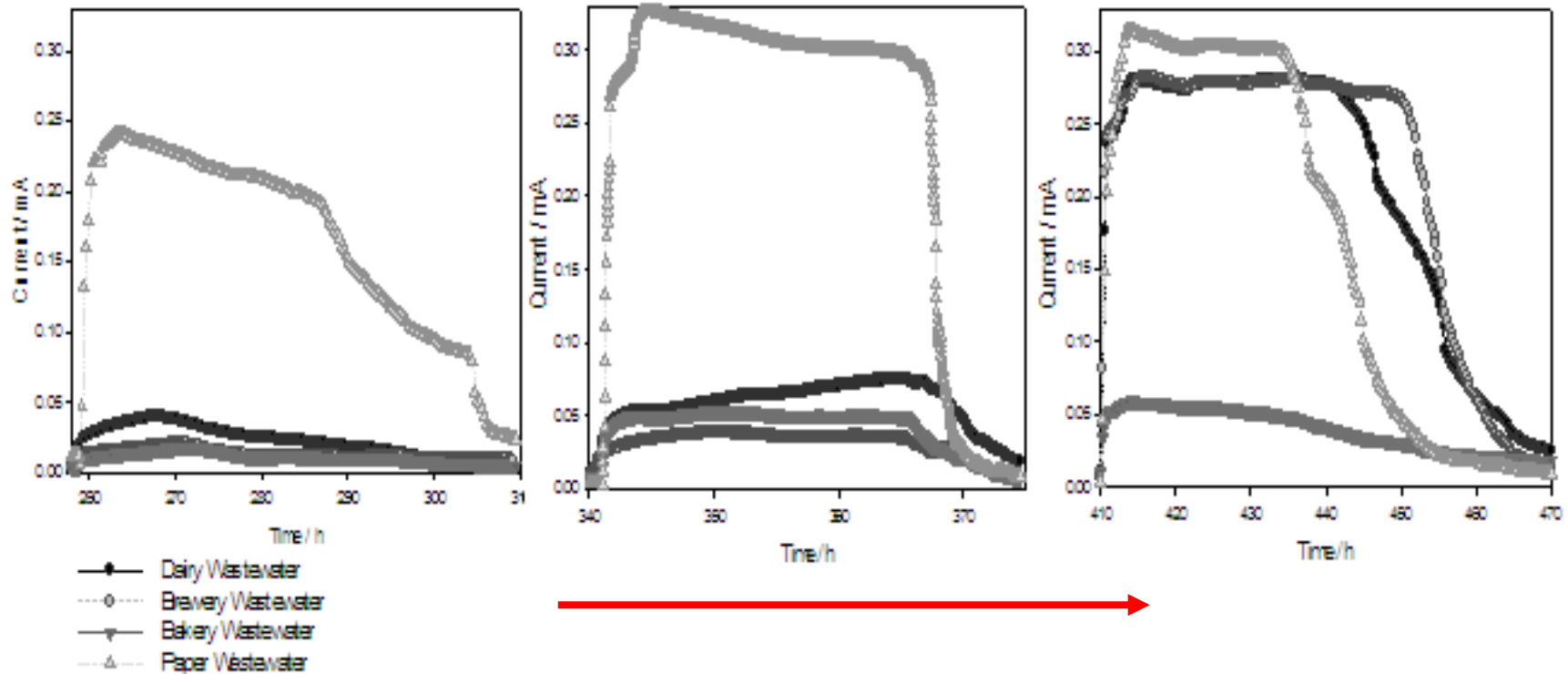
BioBakery  
BioBakery  
BioBreweryWW  
BioBreweryWW  
InocPaperWW  
InocBreweryWW  
BioPaperWW  
BioPaperWW  
InocBakeryWW

# 3. Results: e<sup>-</sup> shuttle mediators

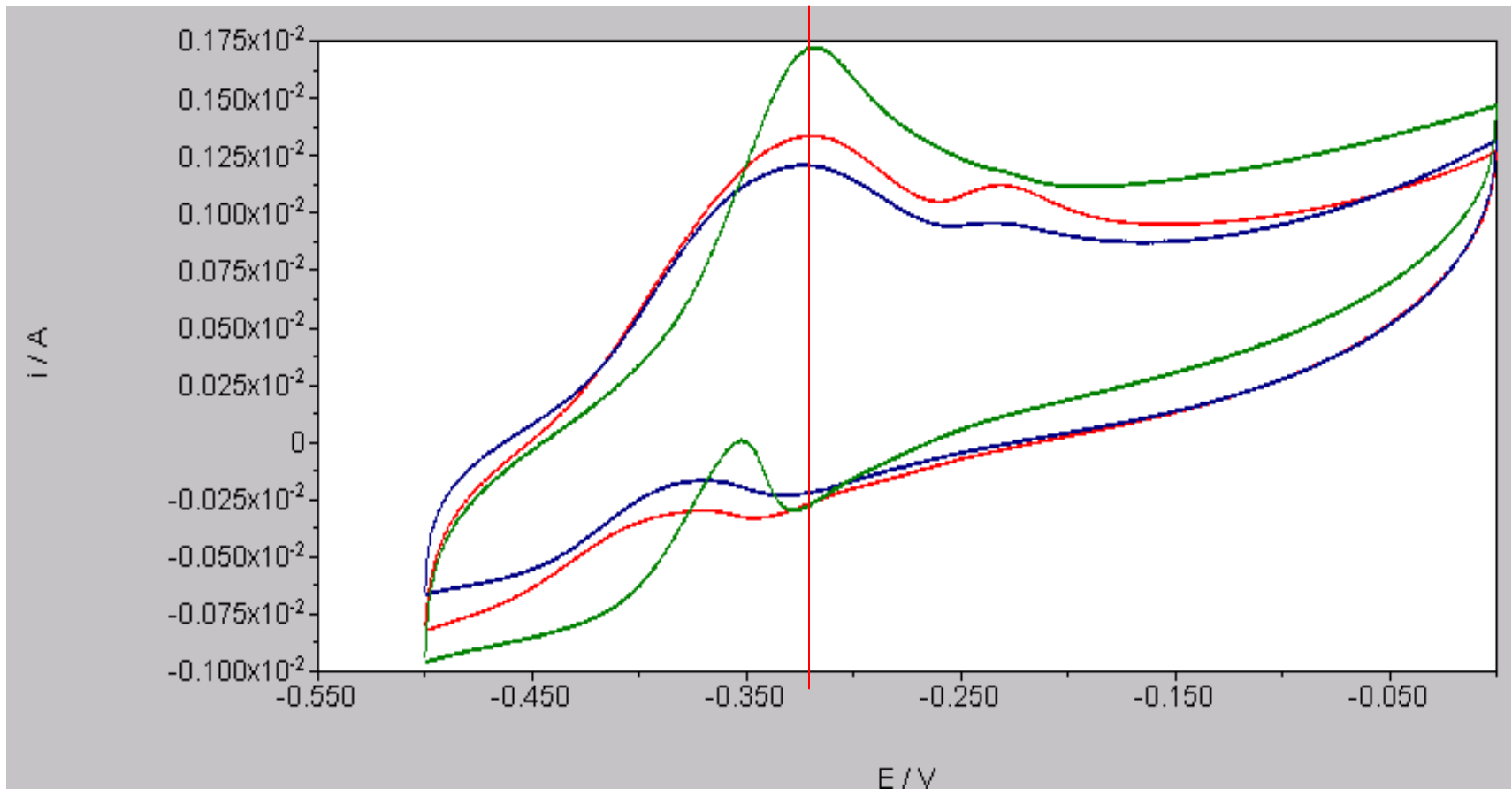


# Are electron shuttle properties transferable?

Conditioning all reactors for one batch with paper wastewater and use again its corresponding wastewater.



# Cyclic voltammetry



green: paper ww, blue: brewery ww, red: dairy ww

# Conclusions

- All MFC systems achieved high COD removal rates although only MFC fed with paper wastewaters developed a high current output.
- MFC microbial biofilm communities differed according to the wastewater type.
- Current output differences were due to the presence of an electron shuttle compound.
- Conductivity partially limited current output in all cases.
- The mediator was in some cases transferable to be used in MFC reactors with different wastewaters.

**Merci !**

