Integrated Desalination and Wastewater Treatment Systems

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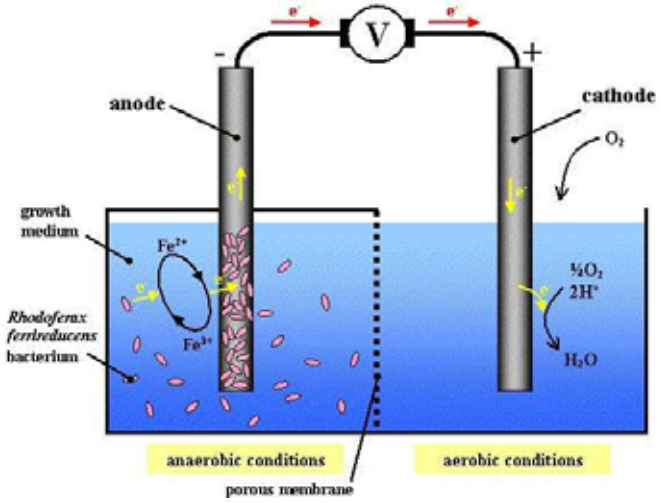
Introduction

- Global water shortages have increased the need for desalination.
- The theoretical minimum energy for desalination of typical seawater (35 g/L of total dissolved solids) is ~1.0 kWh/m3
- the overall energy consumption for desalination of typical seawater (35 g/L of total dissolved solids) is 3 to 4 kWh/m3
- The energy in domestic wastewater typically ranges from 1.8 to 2.1 kWh/m3
- Wastewater has the substrate required for microbial electricity generation

Introduction

- Microbial fuel cells (MFCs) are devices that can use bacterial metabolism to produce an electrical current from a wide range organic substrates.



Bio-Electrochemical Reactions in MFC

Anode Chamber

$$C_6H_{12}O_6 + 12\ H_2O \rightarrow 6\ HCO_3^- + 30\ H^+ + 24\ e^-$$

Or

$$CH_3COO^- + 4\ H_2O \rightarrow 2HCO_3^- + 9\ H^+ + 8\ e^-$$

Cathode chamber

$$O2 + 4\ H+ + 4\ e- \longrightarrow 2\ H2O$$

Introduction

- **Photosynthetic MFC**

In-situ oxygen generation by algae in the cathode chamber

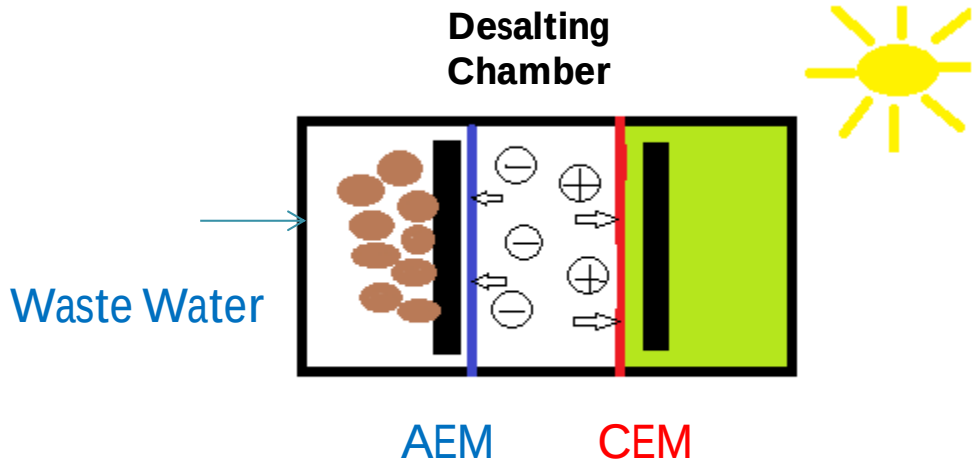
Carbon dioxide + Water + Light energy → carbohydrates + oxygen+ new cells

Introduction

Algal-Microbial Desalination Cells (MDCs)

- MDCs contain an additional chamber installed between cation and anion-exchange membranes in which salts (e.g., NaCl) in seawater are present as cations and anions.

- **Highlights**
- Self sustainable system
- O_2 production/utilization
- Electricity production
- Desalination
- Biofuel production
- Reduced p^H fluctuation
- Water reuse and treatment



Objectives

- Evaluate the effect of presence of algae in cathode part of Microbial Fuel Cells and Microbial Desalination Cells.

- Study the performance of algal MDC in terms of desalination, energy production and wastewater treatment.

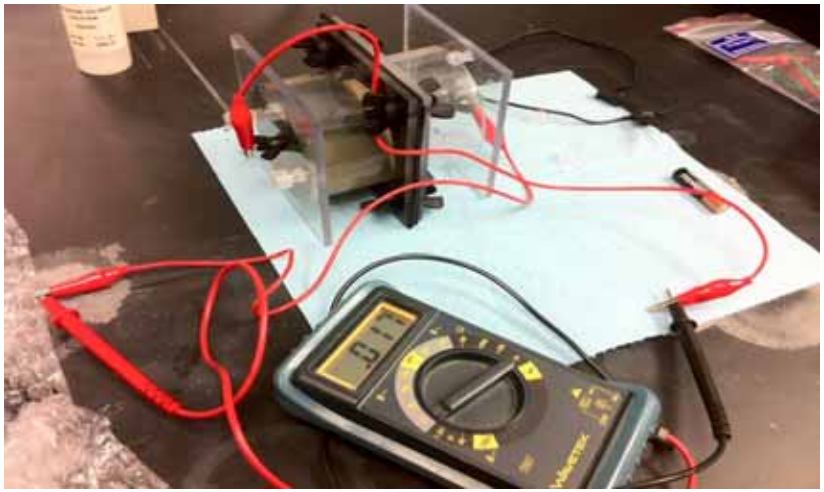
Material and methods

- **Anode:**
- Microbial consortium from wastewater treatment plant in Starkville
- medium used in anode chamber was a synthetic waste water containing: Glucose 281.25 mg/l, KH_2PO_4(4.4 g/l), K_2HPO_4(3.4 g/l), NH_4Cl(1.5 g/l), $MgCl_2$ (0.1 g/l), $CaCl_2$ (0.1 g/l), KCl(0.1 g/l), MnCl2.4H2O(.005 g/l), $NaMo.O_4.2H_2O$(.001 g/l)

- **Cathode:**
- The micro algae which was used in cathode compartment had the following mineral solution: CaCl2(25 mg/l), NaCl(25 mg/l), NaNO3(250 mg/l), MgSO4 (75 mg/l), KH2PO4 (105mg/l), K2HPO4(75 mg/l) , 3 ml of trace metal solution with the following concentration was added to the 1000 ml of the above solution. FeCl3 (.194 g/l), MnCl2(0.082g/l), CoCl2(.16 g/l), Na2Mo.O4.2H2O(.008 g/l), ZnCl2(.005 g/l).

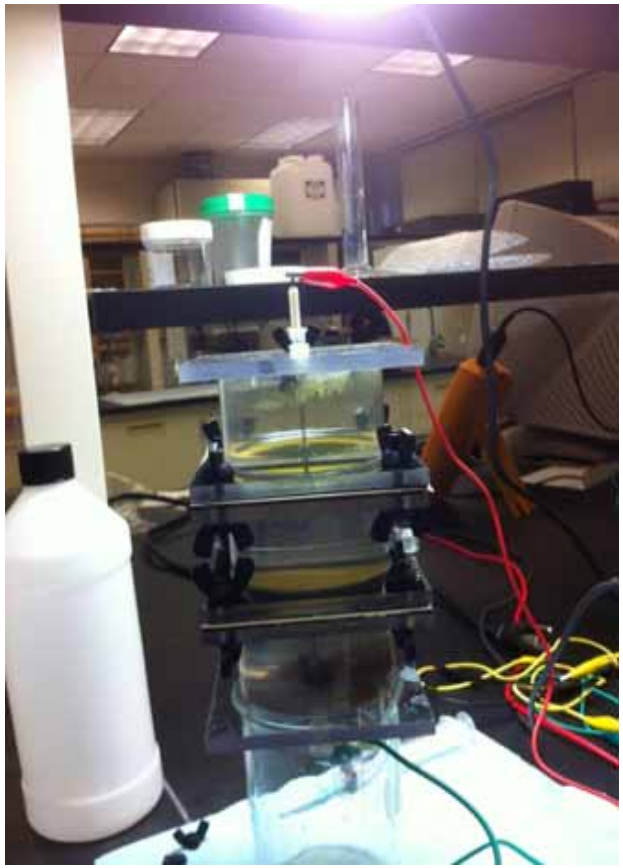
Material and methods

- MFC and MDC Reactors
- 2 plexiglass cylindrical-shaped with 7.2 cm diameter,V=180 ml
- Graphite papers as electrodes
- Cation exchange membrane (CEM, CMI 7000, Membranes international,)
- Anion exchange membrane(AEM, AMI 7001, Membranes international)
- Volume of desalination chamber=200 ml
- Initial NaCl=10 g/l
- Initial COD= 300 and 500 mg/l



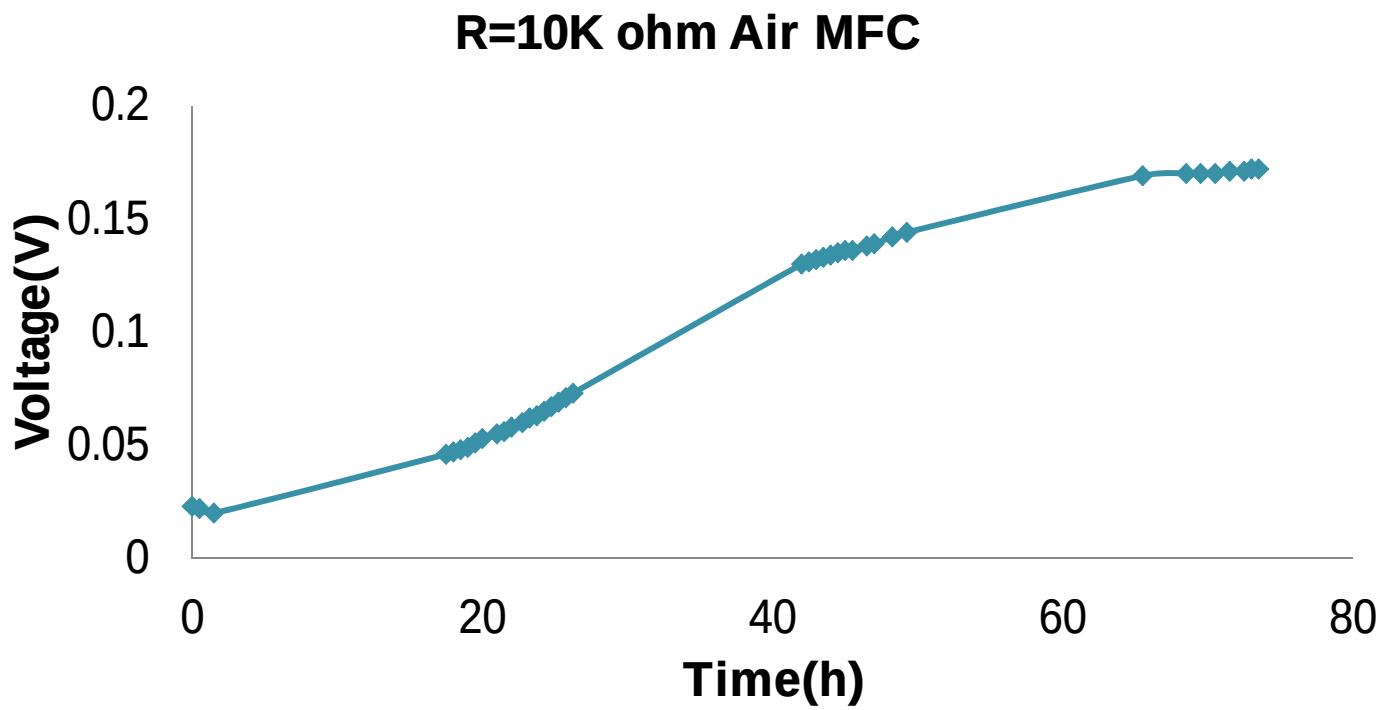
Material and methods

- R=10 K Ω
- Voltage was recorded by a digital Multimeter
- I=V/R
- P=V.I
- COD test were according to APHA method
- Electrical conductivity, TDS removal and salinity removal by a conductivity meter



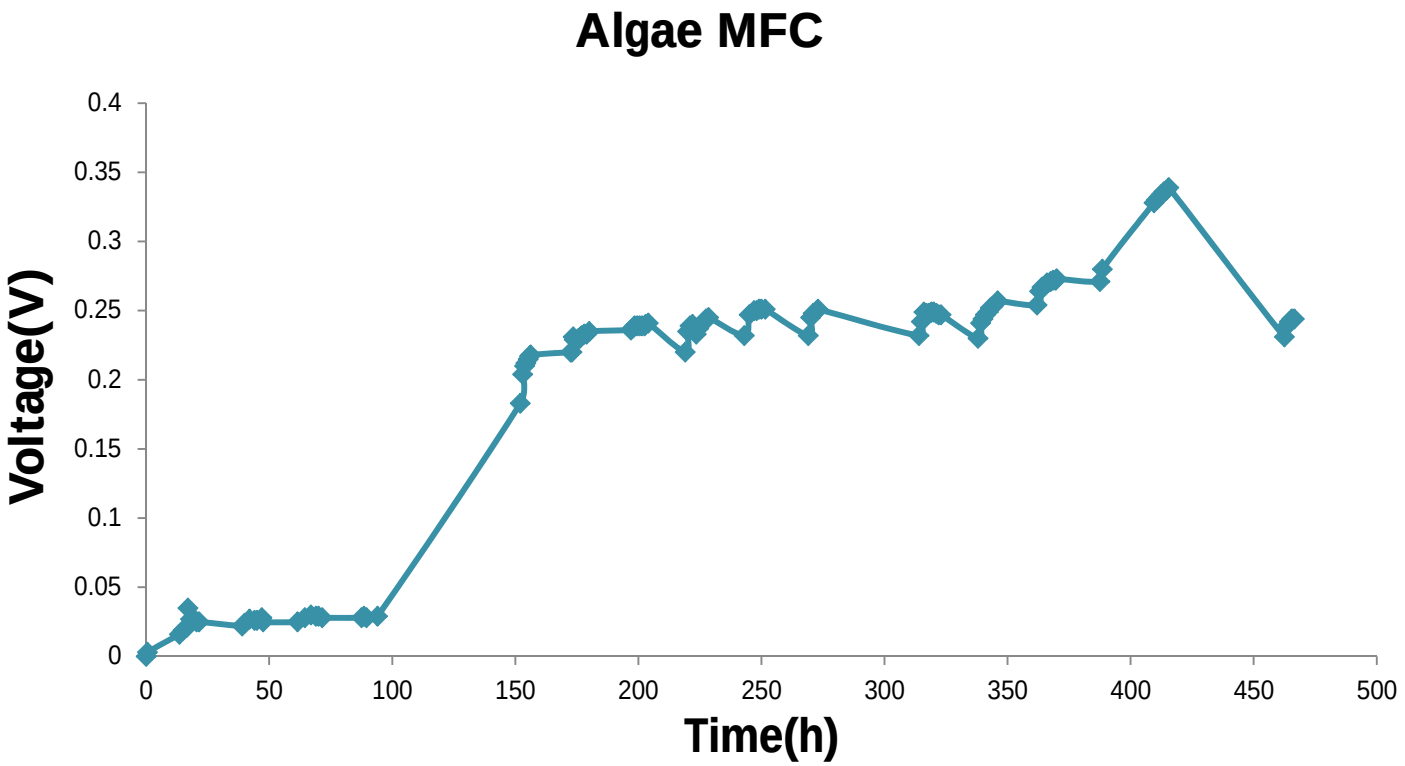
Results

- Air Cathode MFC
- Maximum OCV=0.425 V



Results

- Algal Cathodic MFC
- Maximum OCV=0.488 v



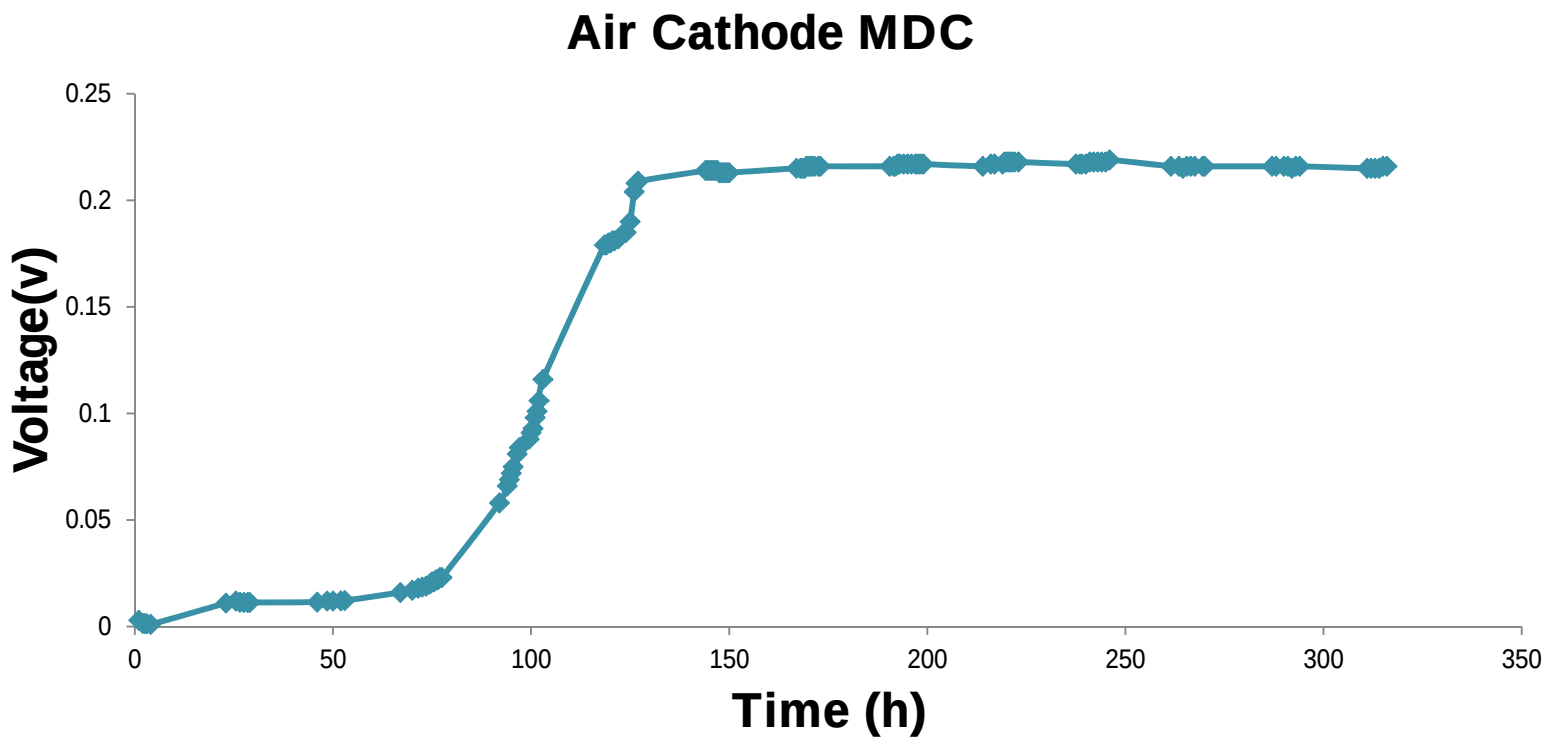
Results

- COD Removal

Type Of MFC	COD Removal	Time
Air Cathode	38.1%	191 h
Air Cathode with air pumping	79.9%	323.75 h
Algal MFC	59.2%	512.5 h

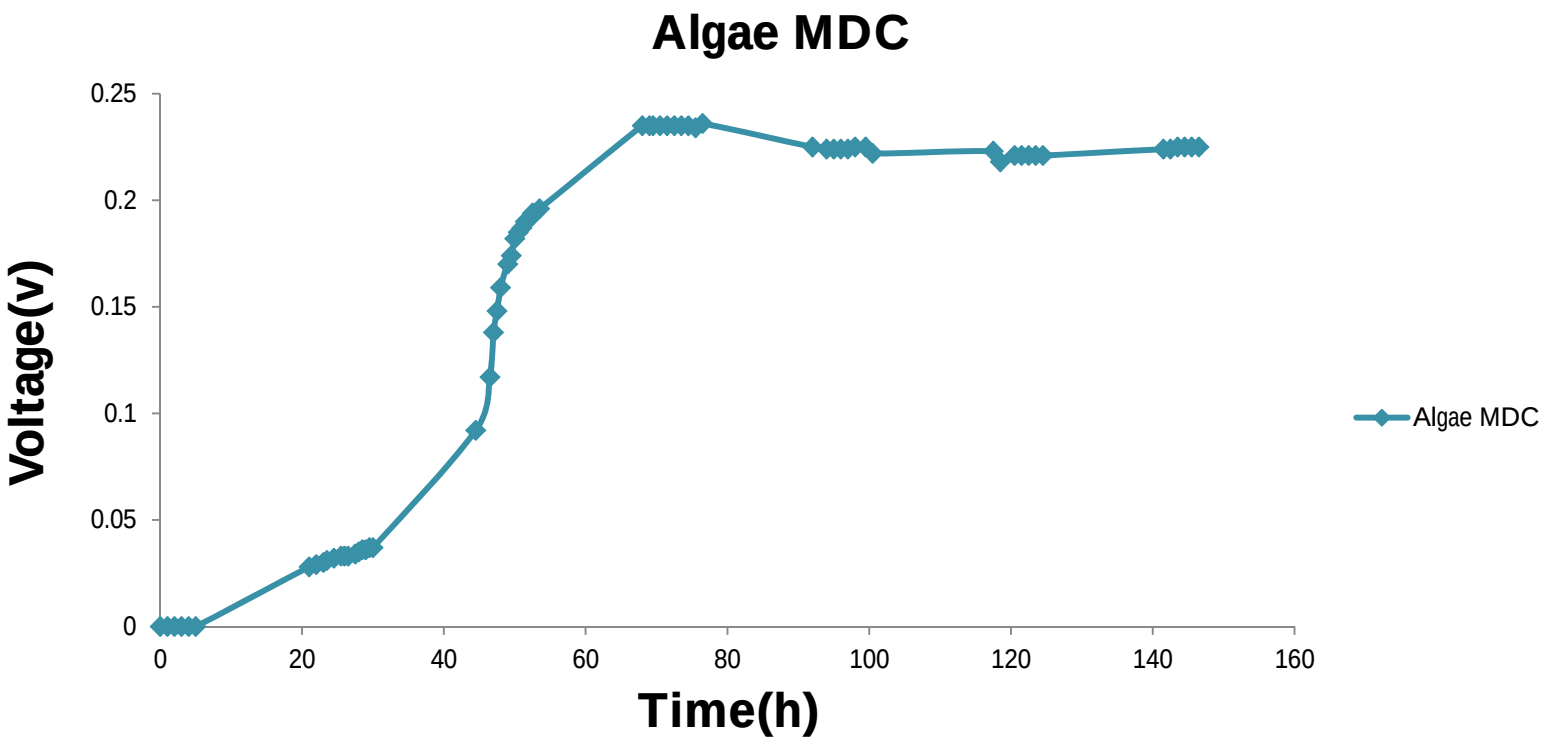
Results

- MDC with Air Cathode
- Maximum Voltage=0.219 v



Results

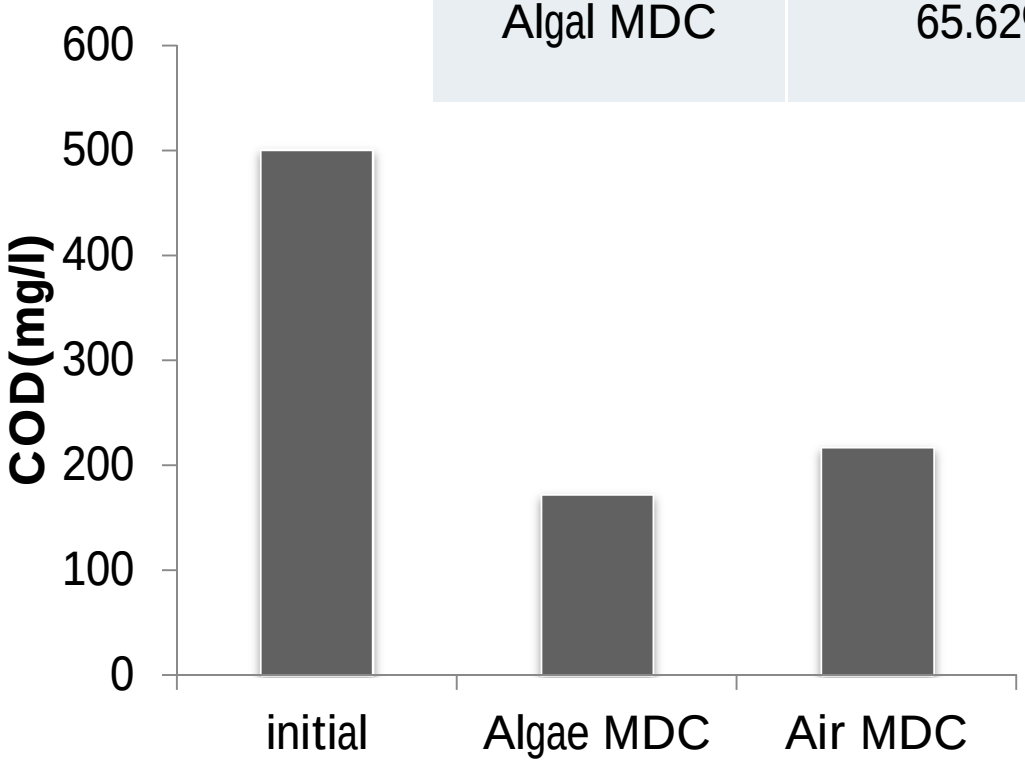
- Algal MDC
- Maximum Voltage=0.236 v



Results

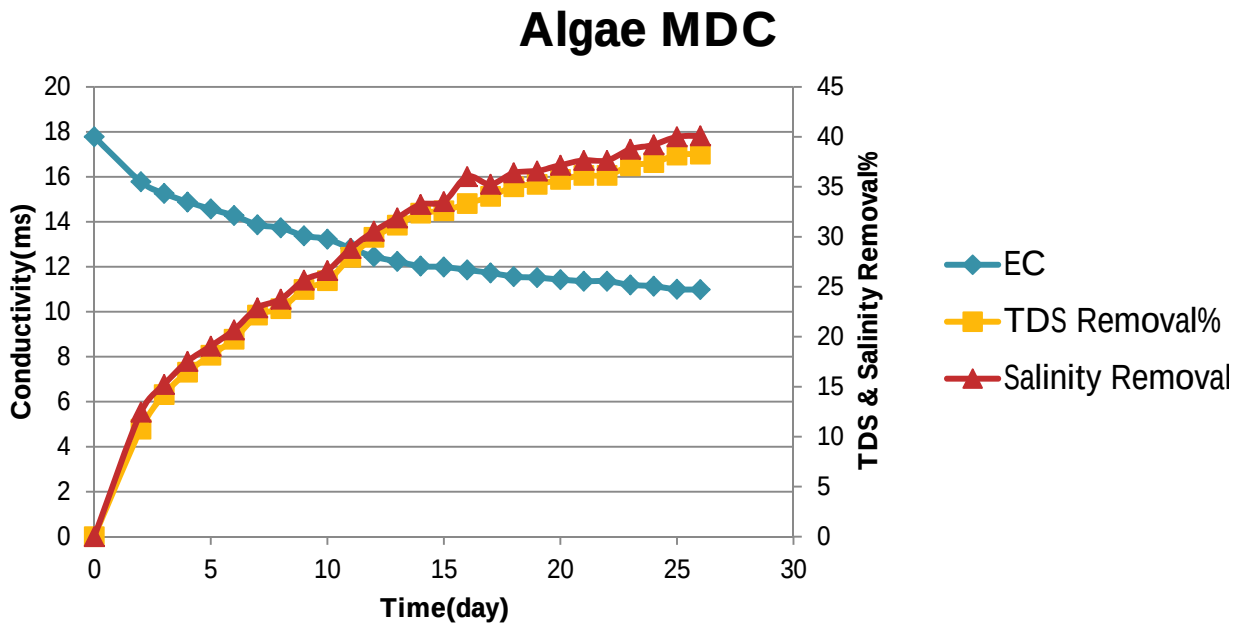
- COD Test

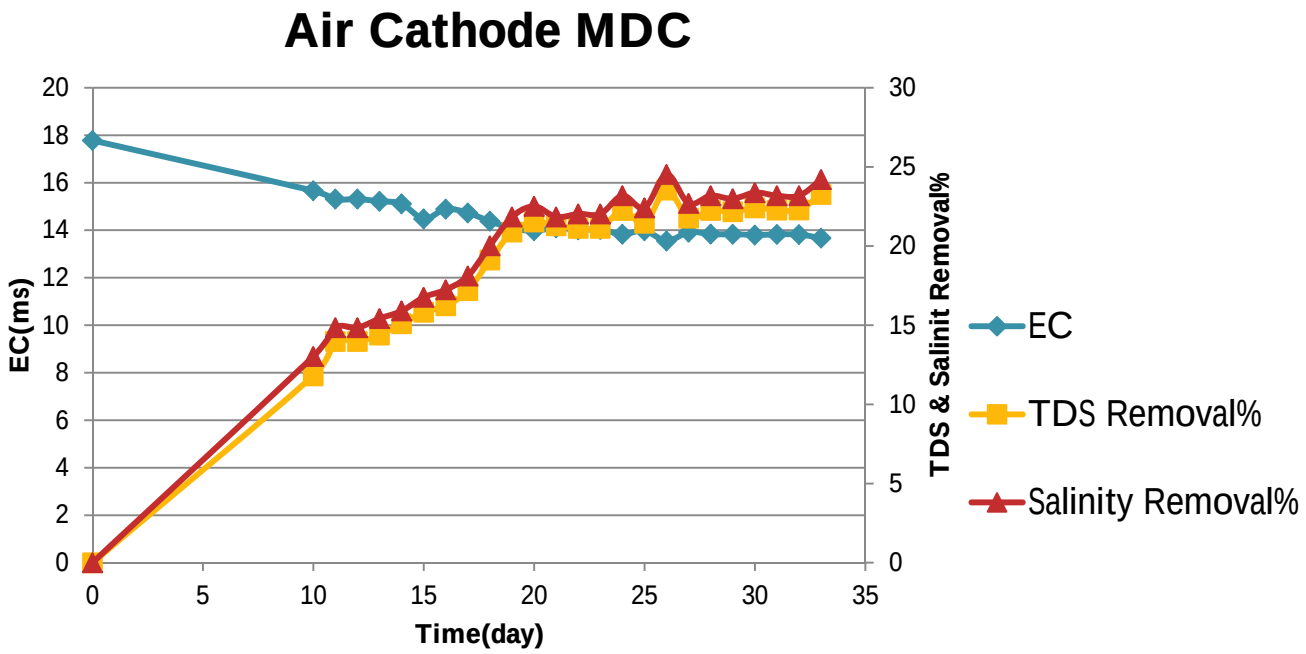
MDC Type	COD removal	Time h
Air Cathode	56.65%	316
Algal MDC	65.62%	146.5



Results

- Salinity Test





Conclusions

- Algal MFC and MDC can improve electricity production by in situ-oxygen providing
- The salinity removal rate for algal MDC was much better than the air cathode MDC
- MFC and MDC Systems Can remove organic materials of waste water
- This study demonstrates the feasibility of practical application of Algal biocathode MDCs as a sustainable method for water desalination

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Thank You!
Any Question?