

# Voltage optimization and antibiotics removal in a microbial electrolysis cell using concentrated sludge as substrates

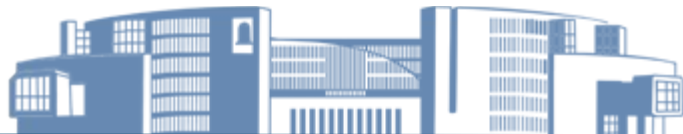


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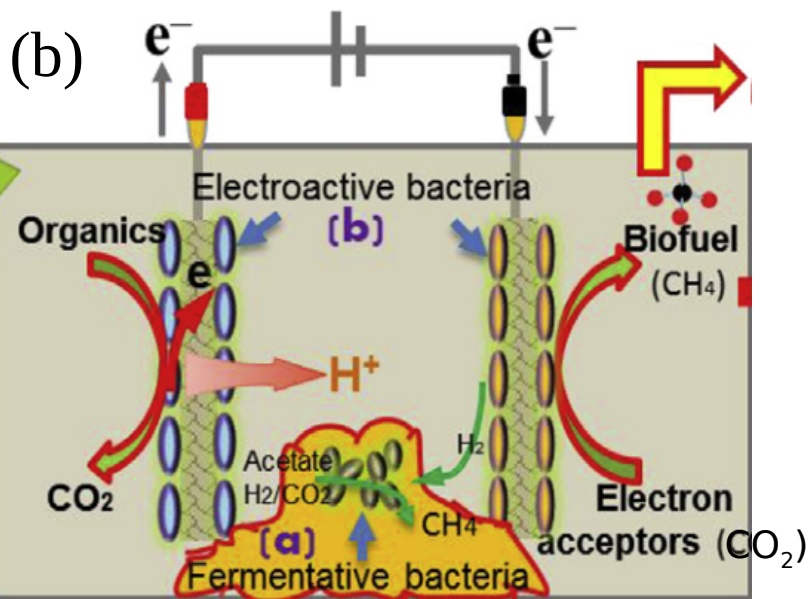
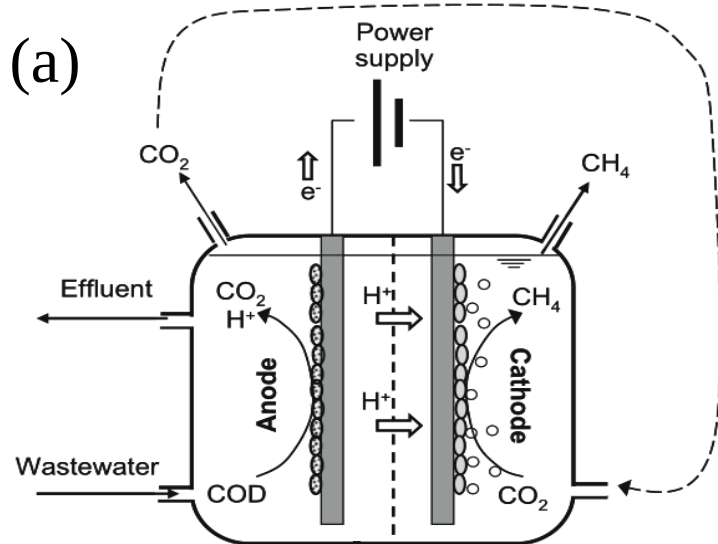
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# Introduction



## Advantages:

Accelerate reaction rate

Improve system stability

Promote decomposition of refractory organics

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**Concentrated  
sludge**

## Overcome:

Slow hydrolysis and acidification rate

Methanogenesis substrate restrictions

Vulnerable process stability

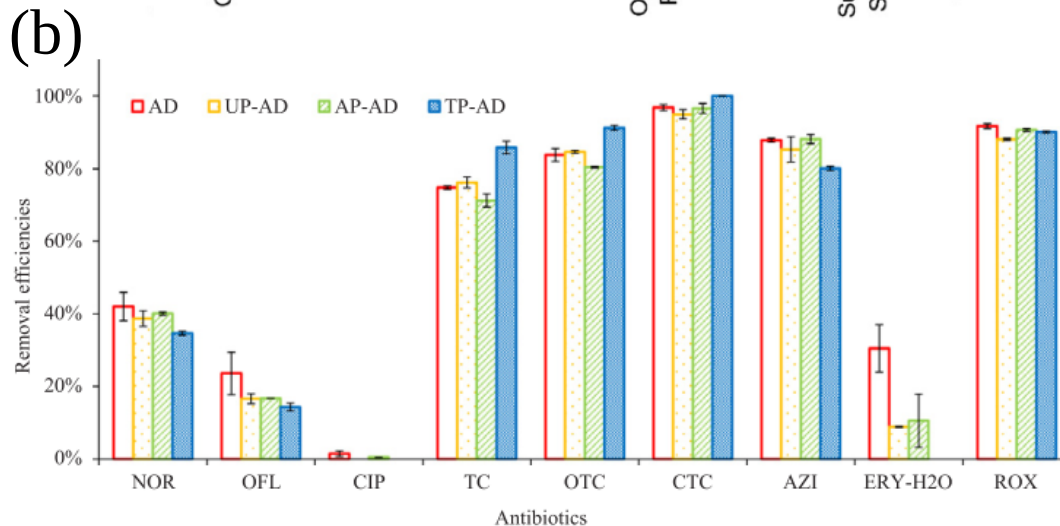
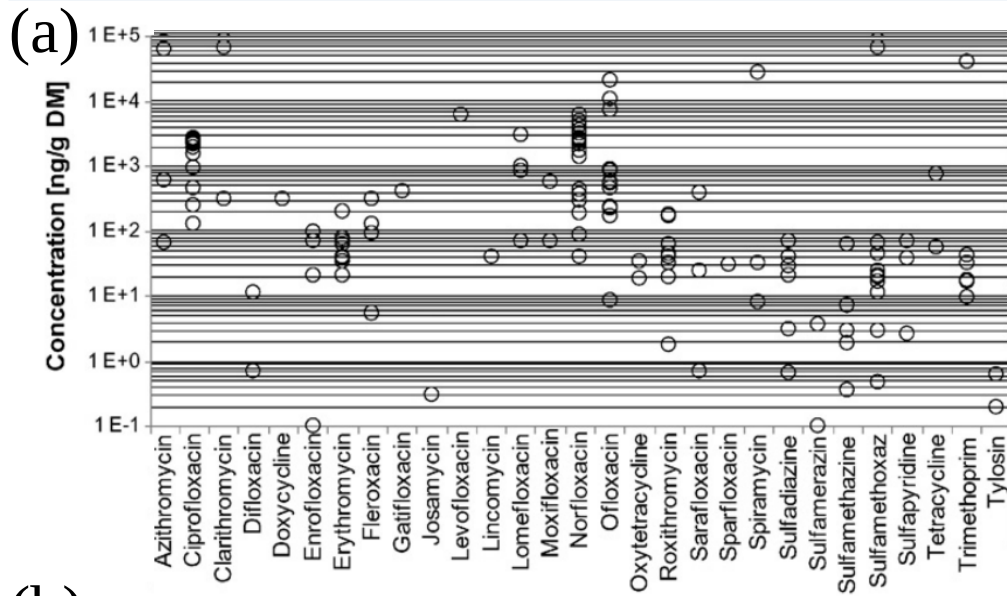
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(a. M. Villano, F. Aulenta, C. Ciucci, et al. Bioresource Technology, 2010)

(b. G. Zhen, T. Kobayashi, X. Lu, et al. Chemosphere, 2016)

# Introduction

MECs treating sludge mainly focused on **organic matters removal** (COD and VS) and **energy recovery** ( $H_2$  and  $CH_4$ ).



Antibiotics removal in MEC treating sludge has been rarely reported. Gradient redox potential and pH, as well as specific bioelectrodes niche might be helpful to their degradation.

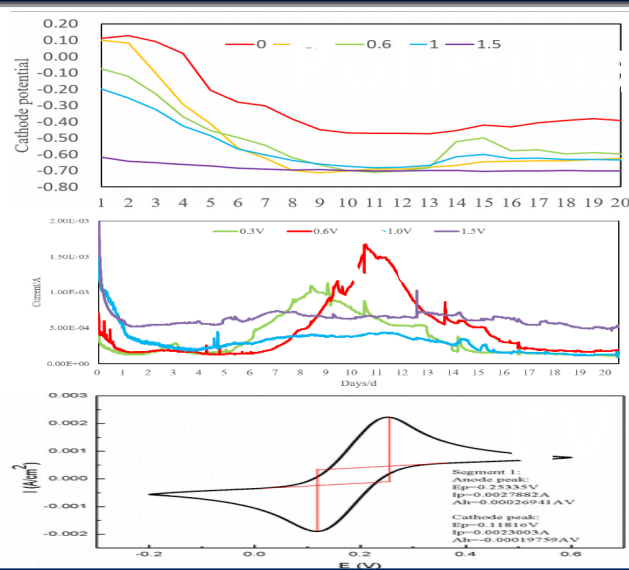
(a. P. Verlicchi, E. Zambello. Science of the Total Environment, 2015)

(b. X. Zhang, R. Li. Bioresource Technology, 2018)

# Introduction

## Applied voltage

### Electrochemical performance



### Microbial distribution

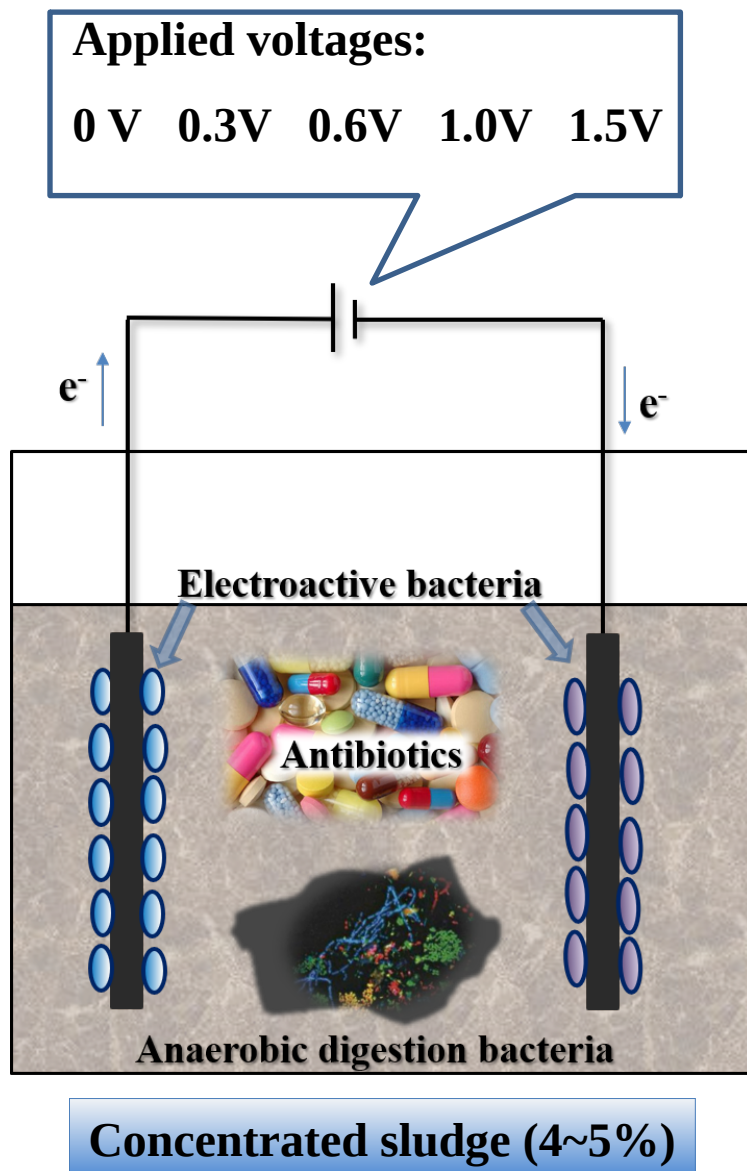


Electrode  
biofilms



Suspended  
microbials

# Experiment



## Electrochemical performance

Current  
Cathode potential

## Antibiotics removal

### Tetracycline

Tetracycline (TC)  
Oxytetracycline (OTC)  
Chlortetracycline (CTC)

### Fluoroquinolones

Norfloxacin (NOR)  
Ciprofloxacin (CIP)  
Ofloxacin (OFL)

### Macrolides

Roxithromycin (ROX), Azithromycin (AZI)  
Dehydrated erythromycin (ERY-H<sub>2</sub>O)

## Microbials responses

### Suspended microbial

Viability  
Activity  
Composition

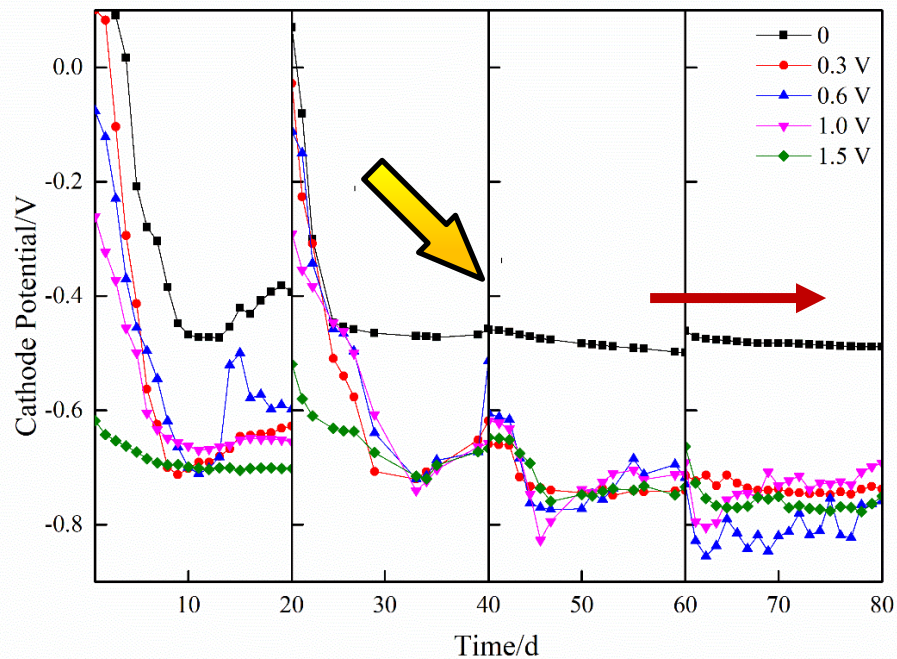
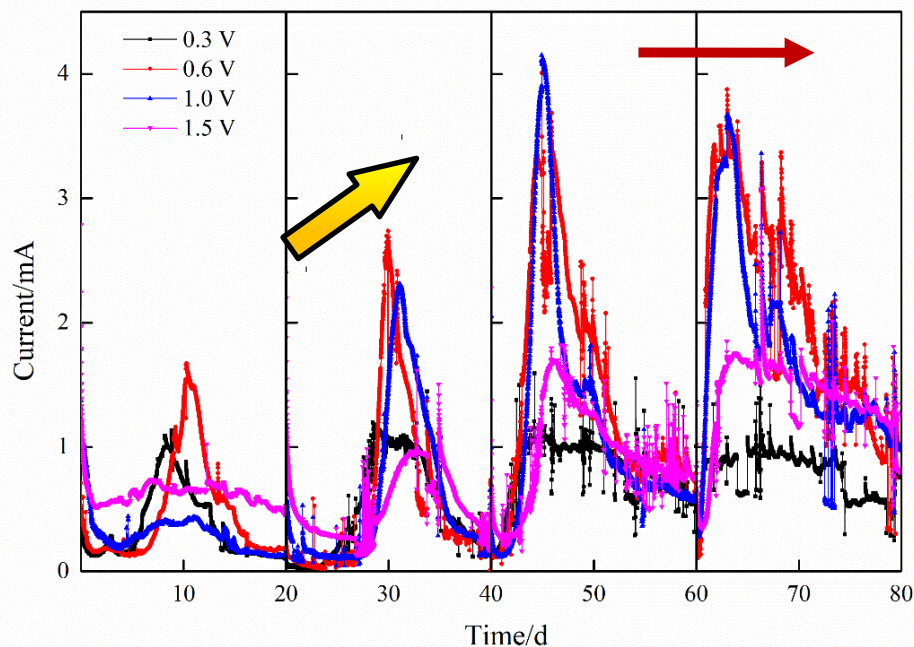
### Electrode biofilms

Enrichment  
Visualization



# Results and Discussion

	Average current (mA)	Peak current (mA)	Average cathode potential (V)	Average anode potential (V)
0	<b>0.6 V &gt; 1.0 V &gt; 1.5 V &gt; 0.3 V</b>		-0.481	-0.479
0.3 V	0.79	1.76	-0.735	-0.450
0.6 V	2.03	3.87	<b>-0.804</b>	-0.294
1.0 V	1.71	3.67	-0.735	0.235
1.5 V	1.37	3.08	-0.758	0.697



**Fig. 1.** Current development and cathode potential development during the startup of MECs under different applied voltages.

# Results and Discussion

Table 2. The concentration of antibiotics in the initial mixed sludge

Antibiotics	NOR	CIP	OFL	TC	OTC	CTC	AZI	ERY-H <sub>2</sub> O	ROX
Concentration (µg/kg dry weight)	1534.51	452.81	2894.71	120.12	850.49	15.88	445.33	9.22	10.92
	(30.51)	(0.54)	(37.40)	(2.56)	(4.63)	(0.39)	(35.66)	(1.61)	(0.12)

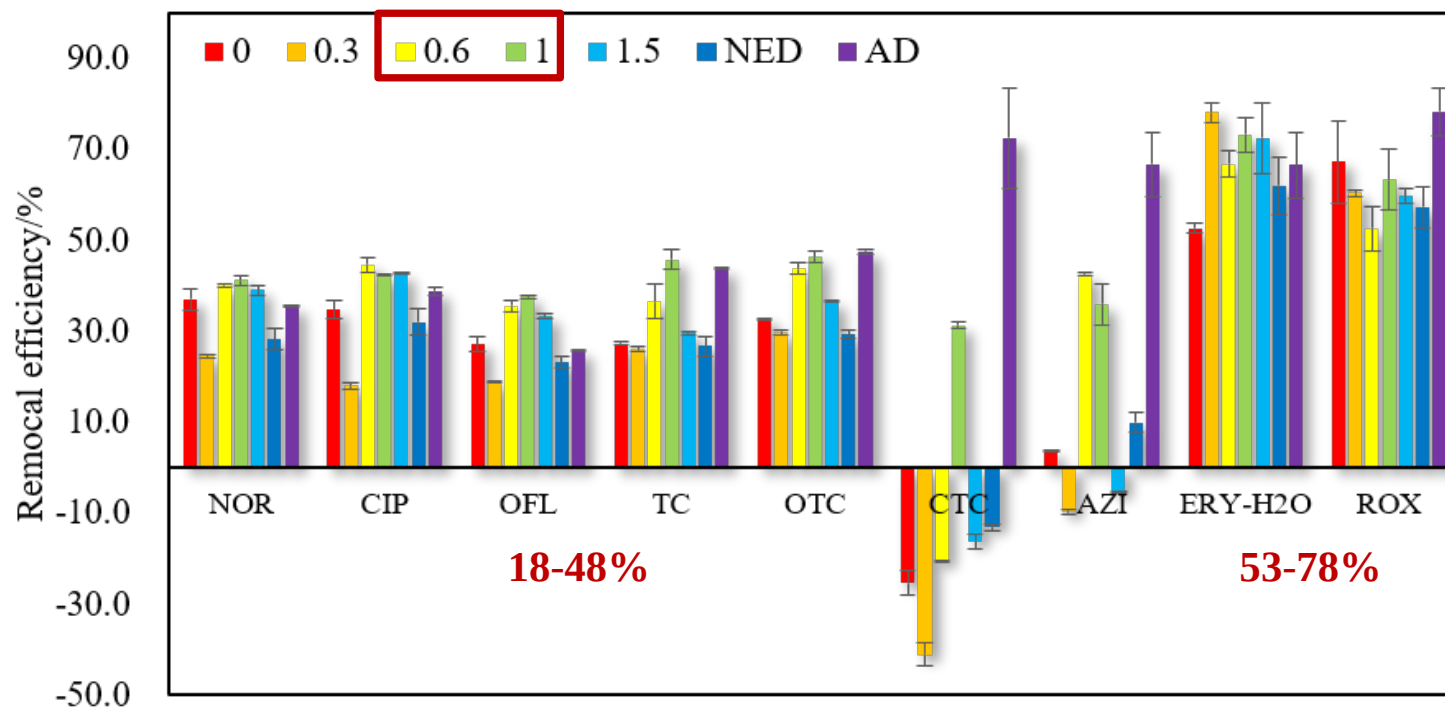
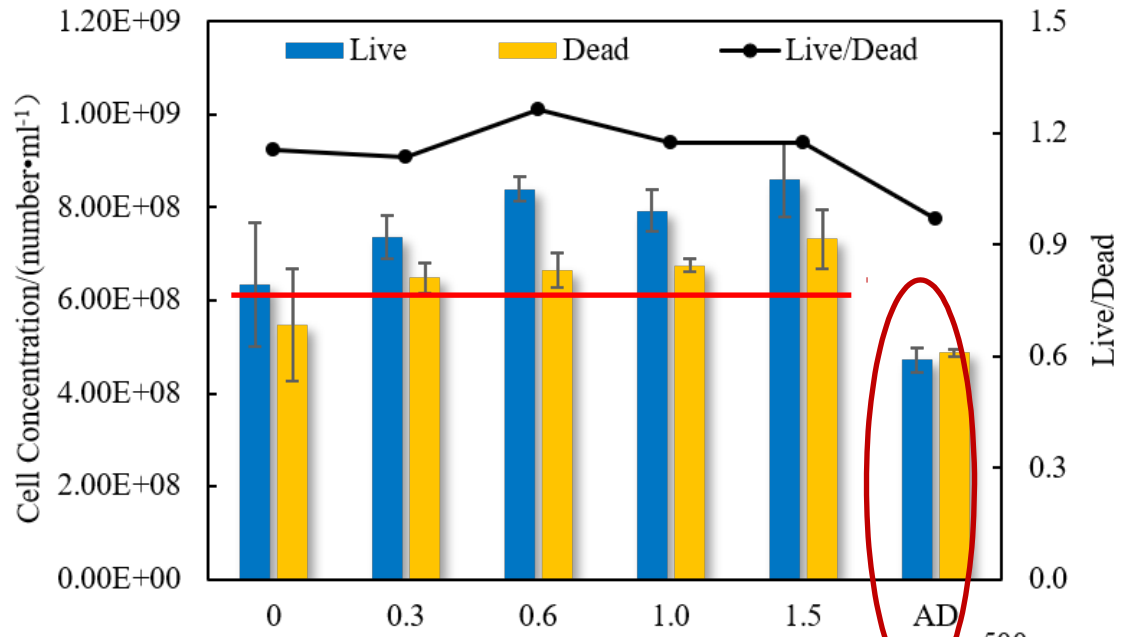
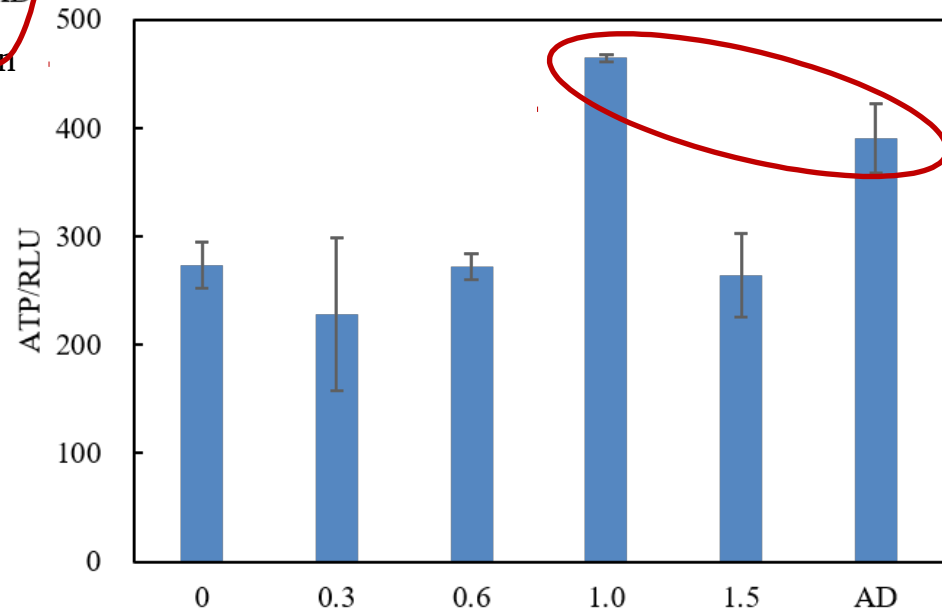


Fig. 2. Removal efficiencies of antibiotics in MECs under different applied voltages.

# Results and Discussion

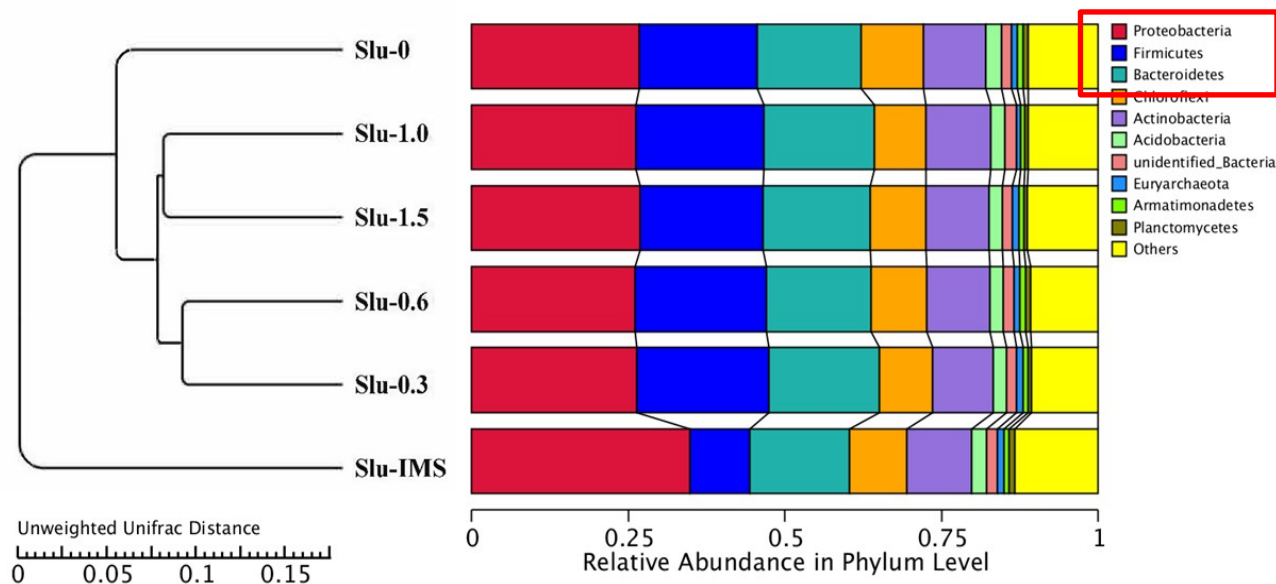


**Fig. 3.** Suspended sludge microorganism viability and ATP in different applied voltages MECs and anaerobic digestion (AD).

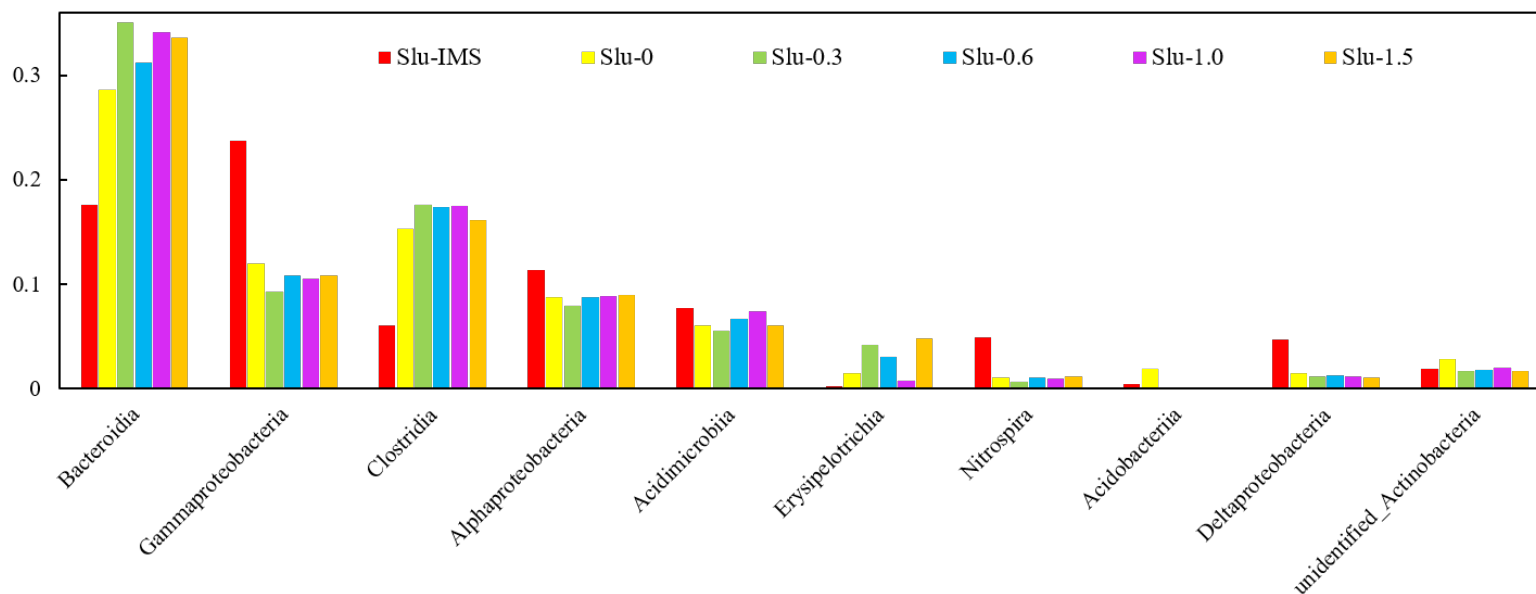




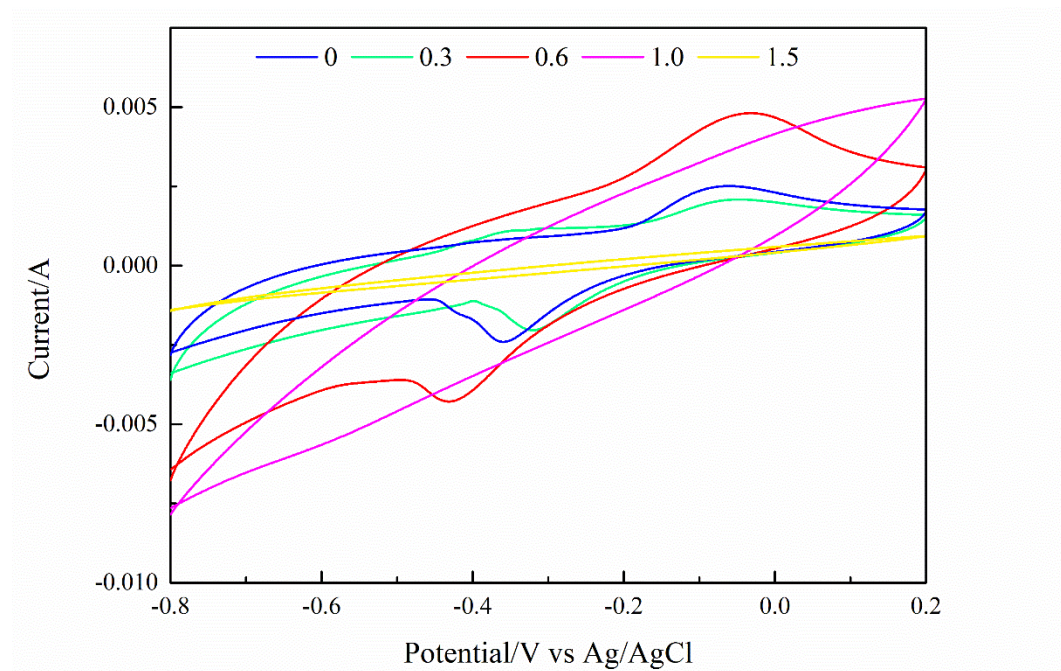
# Results and Discussion



**Fig. 4.** Unweighted unifrac distance, relative abundance at phylum level and class level of suspended sludge microorganisms in raw sludge (IMS) and different applied voltages MECs.



# Results and Discussion

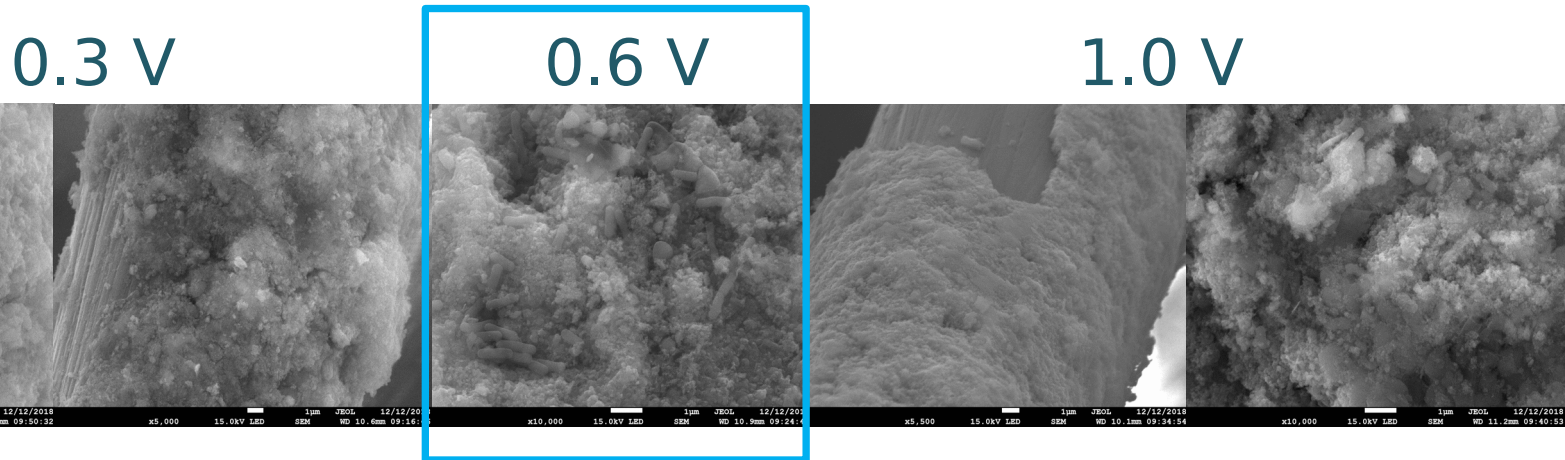
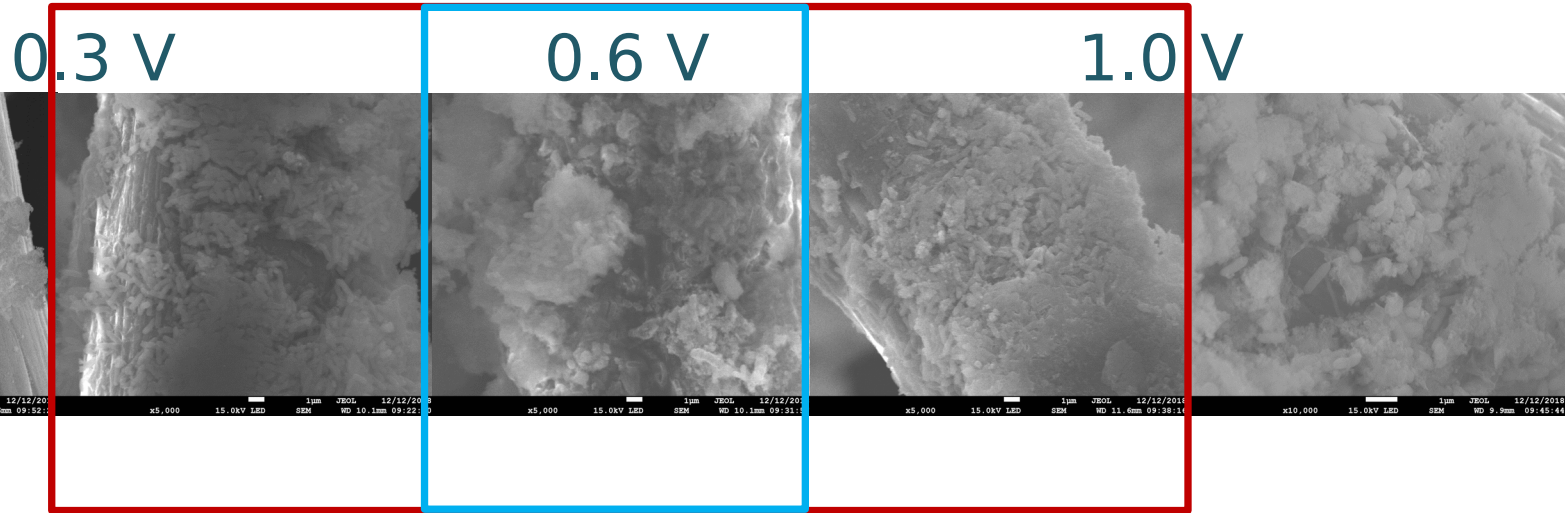


**Fig. 5.** Cyclic voltammetry (CV) profile of bioanodes under different applied voltages in PBS.

Anode	Oxidation peak (mA)	Maximum oxidation current (mA)
0	3.6	2.42
0.3 V	5.32	3.65
0.6 V	9.39	5.9
1.0 V		9.15
1.5 V		1.37

# Results and Discussion

## Anode



**Fig. 6.** Scanning electron micrographs (SEM) of anode and cathode biofilms enriched under different applied voltages.

# Results and Discussion

Table 3. Distribution of elements on cathodes under 0.6V and 1.5V

Elements	0.6 V (Wt%)	1.5 V (Wt%)
C	50.0 ± 0.3	40.6 ± 0.4
O	26.0 ± 0.2	26.8 ± 0.3
F	8.3 ± 0.2	6.6 ± 0.2
P	4.3 ± 0.1	7.8 ± 0.1
K	3.0 ± 0.1	5.8 ± 0.1
Pt	2.3 ± 0.2	2.6 ± 0.3
Fe	2.2 ± 0.1	3.2 ± 0.1
Ca	1.6 ± 0.0	3.0 ± 0.1
Al	1.1 ± 0.0	2.6 ± 0.0
Mg	0.6 ± 0.0	0.3 ± 0.0
S	0.6 ± 0.0	0.8 ± 0.0

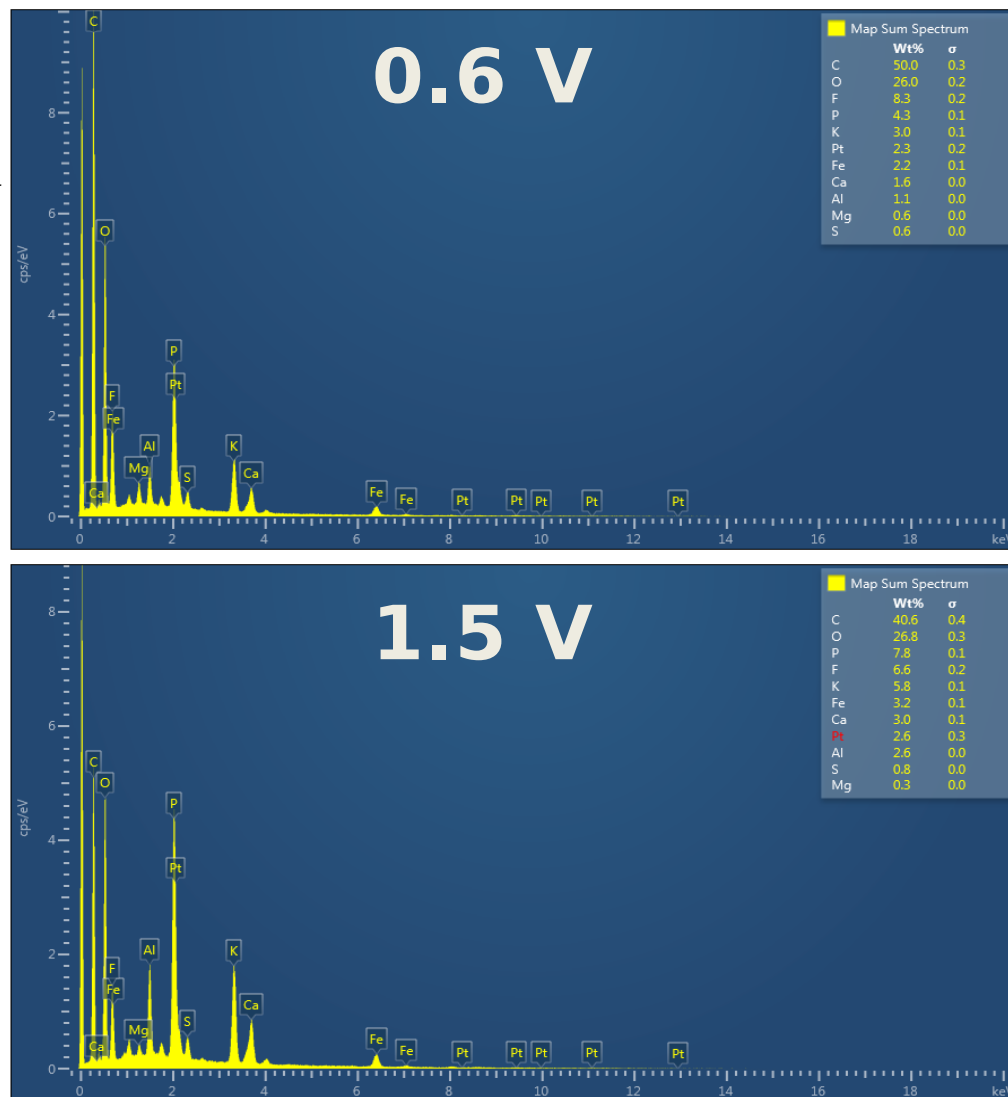


Fig. 6. SEM-EDS elements analysis of cathodes at 0.6 V and 1.5 V.



## Conclusions

- The antibiotics removal efficiencies of **18.1-78.4%** in MECs at room temperature were comparable to that in mesophilic AD.
- Different applied voltages had little effect on **the suspended sludge microorganisms viability, activity and composition** even up to 1.5V.
- Neither electrochemical reaction nor the suspended sludge microorganisms was the driving force for the enhanced removal of antibiotics. **Electrodes had bioaugmentation effects** on the enhanced removal of antibiotics.



# Thanks for your listening!



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