Bioelectrochemical Systems for In Situ Treatment of Groundwater Contaminated by Hexavalent Chromium

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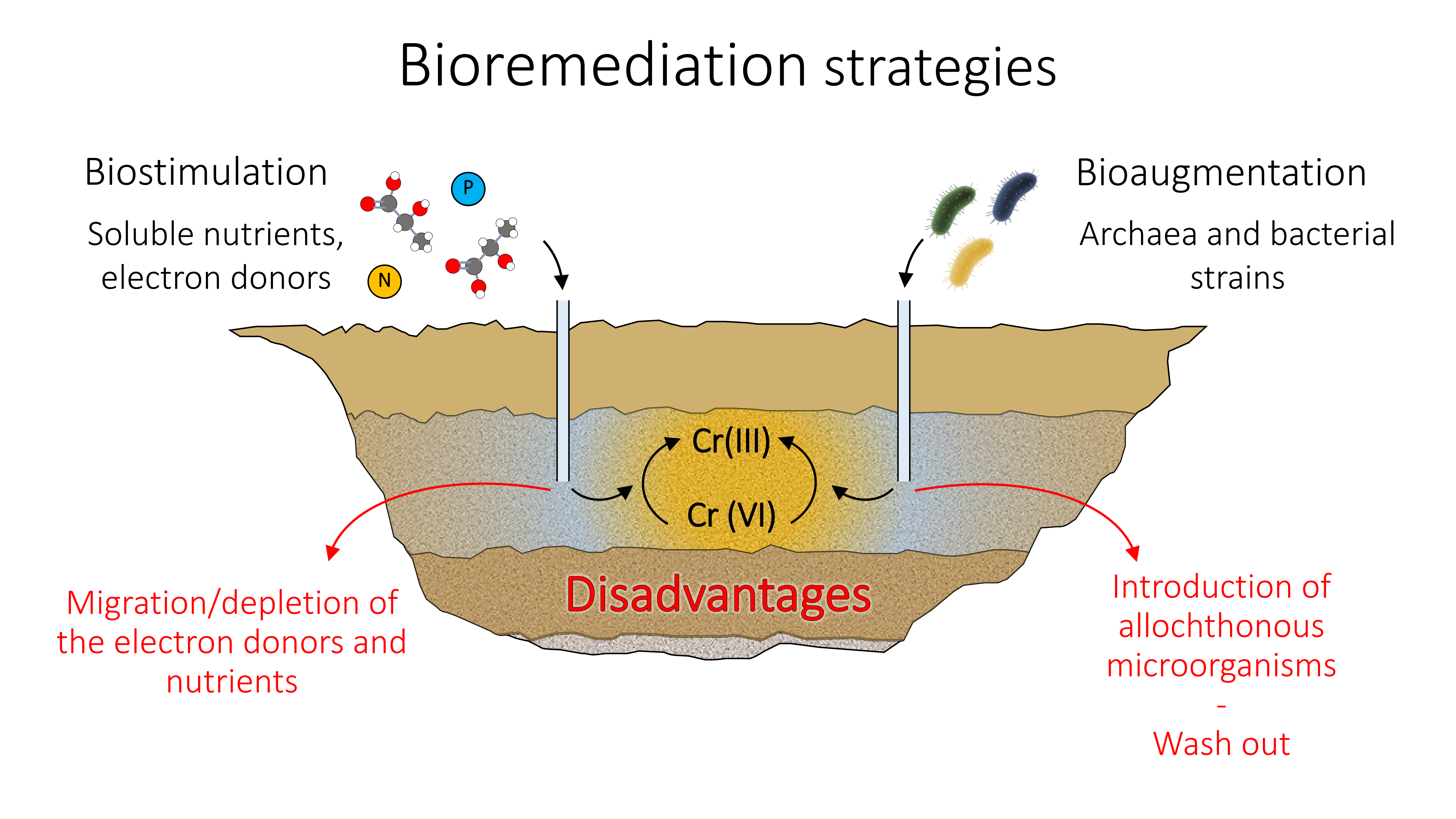
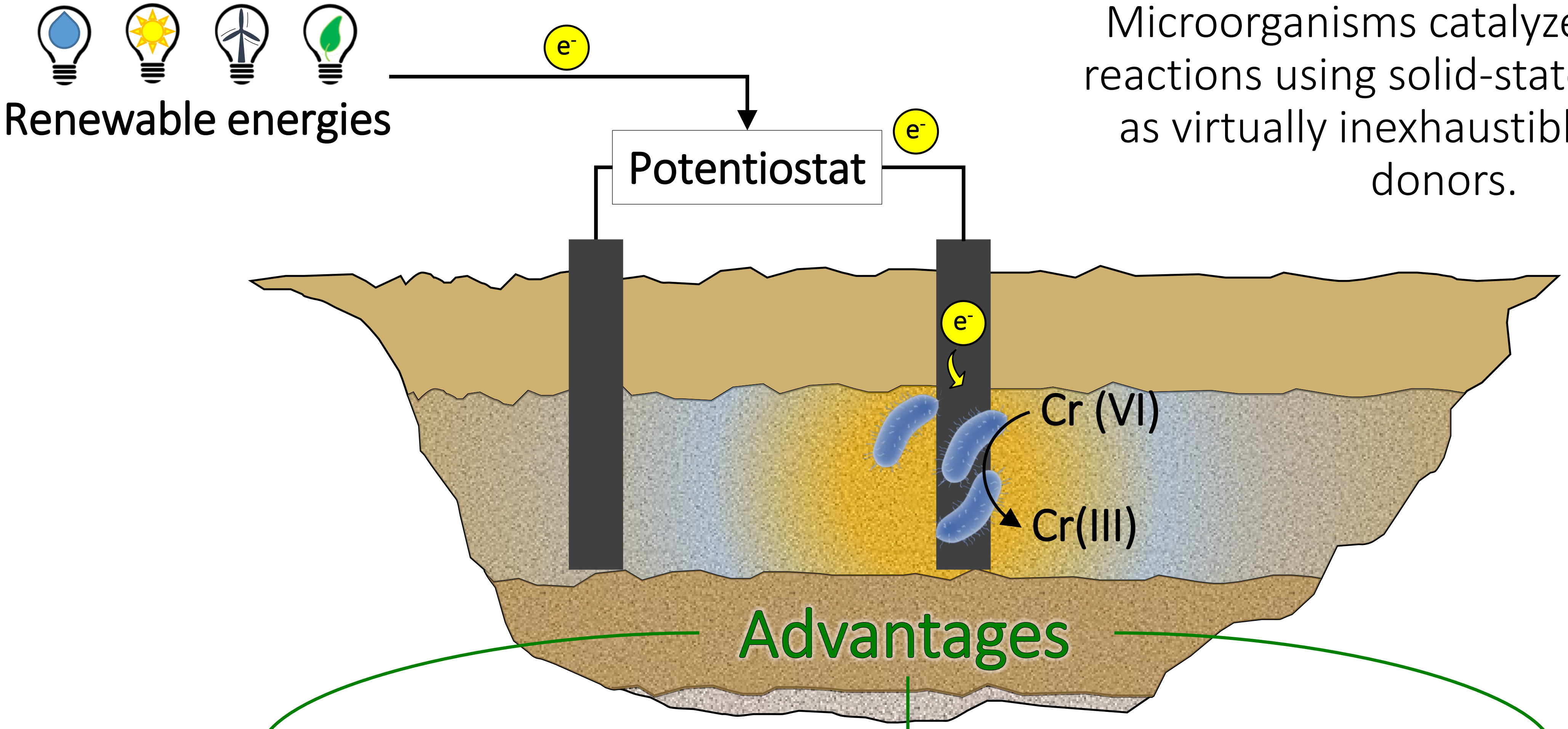
Hexavalent Chromium pollution

- **Cr(VI)** → ($HCrO_4^-$, CrO_4^{2-}): very **soluble**, **mobile** and **carcinogenic** to humans.
- **Highly carcinogenic and wide spread contaminat in groundwater**
- **Innovative** in situ technologies have been considered in **replacement** of the traditional **Pump & Treat** approach.
- **Environmental and economic sustainability** → technologies based on biological mechanisms.


Bioremediation strategies
Biostimulation
Soluble nutrients,
electron donors
P
N
Bioaugmentation
Archaea and bacterial
strains
Cr(III)
Cr (VI)
Disadvantages
Migration/depletion of
the electron donors and
nutrients
Introduction of
allochthonous
microorganisms
-
Wash out

Bioelectrochemical remediation



Microorganisms catalyze reduction reactions using solid-state electrodes as virtually inexhaustible electron donors.

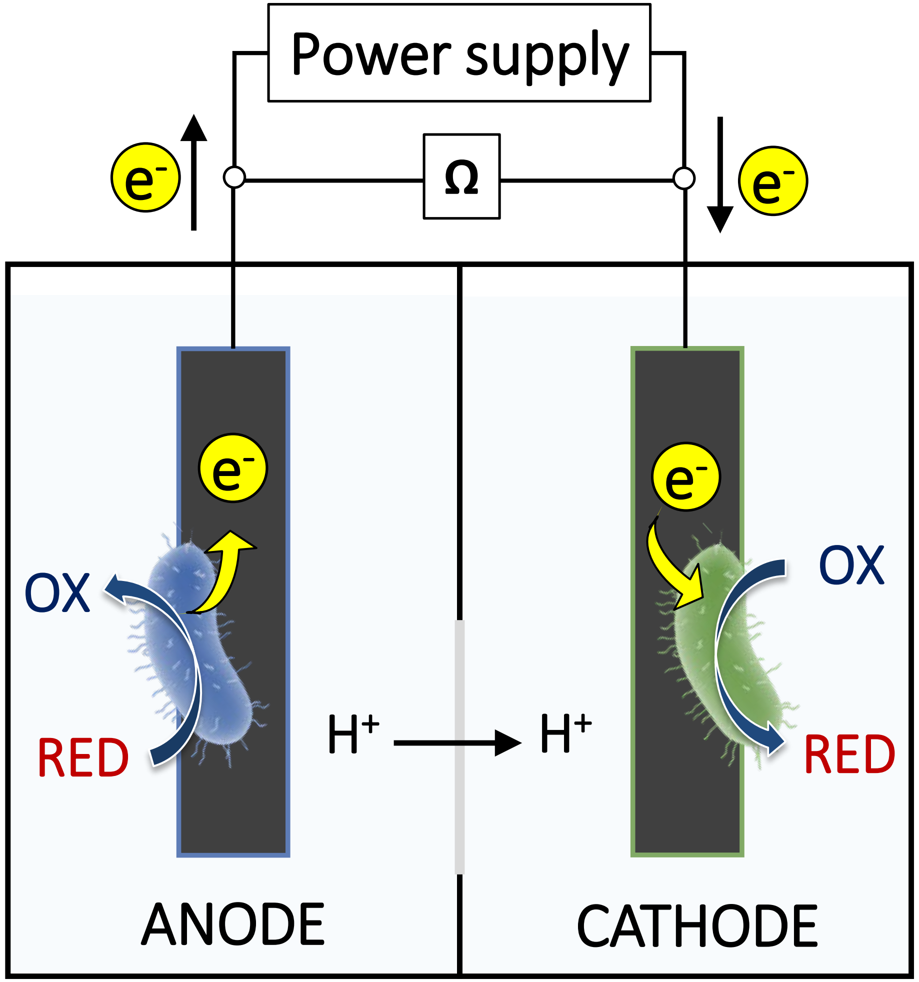
Advantages

Easy electrons delivery and distribution

Avoid formation of unwanted products (CH_4)

Biosensor of degradation process

BioElectrochemical Systems (BESs)

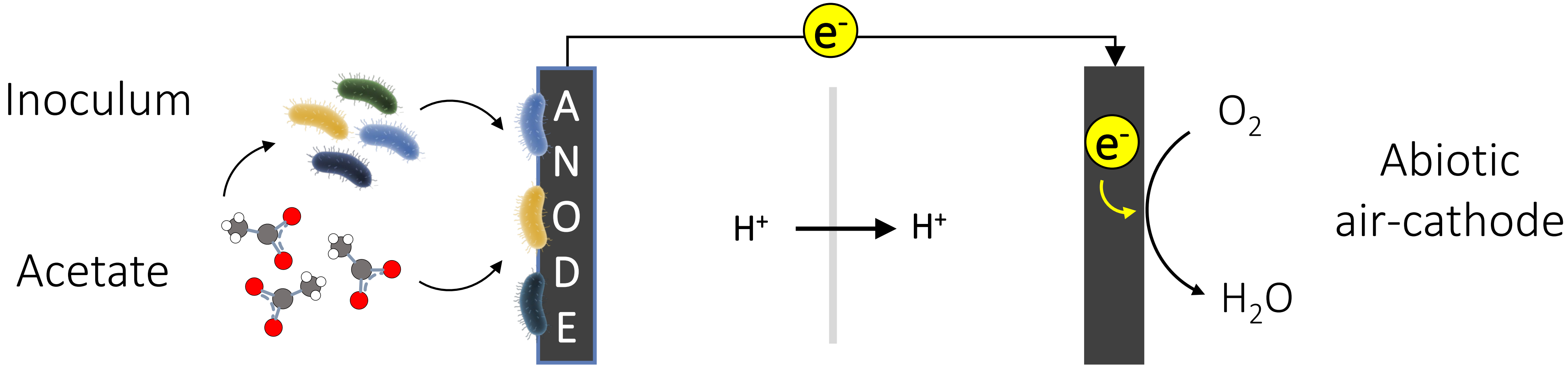


BESs include a set of technologies that exploit the ability of certain **microorganisms** to use the electrodes as electrons acceptors/donors and to **catalyze** redox reactions in order to produce a **flow of electrons**.

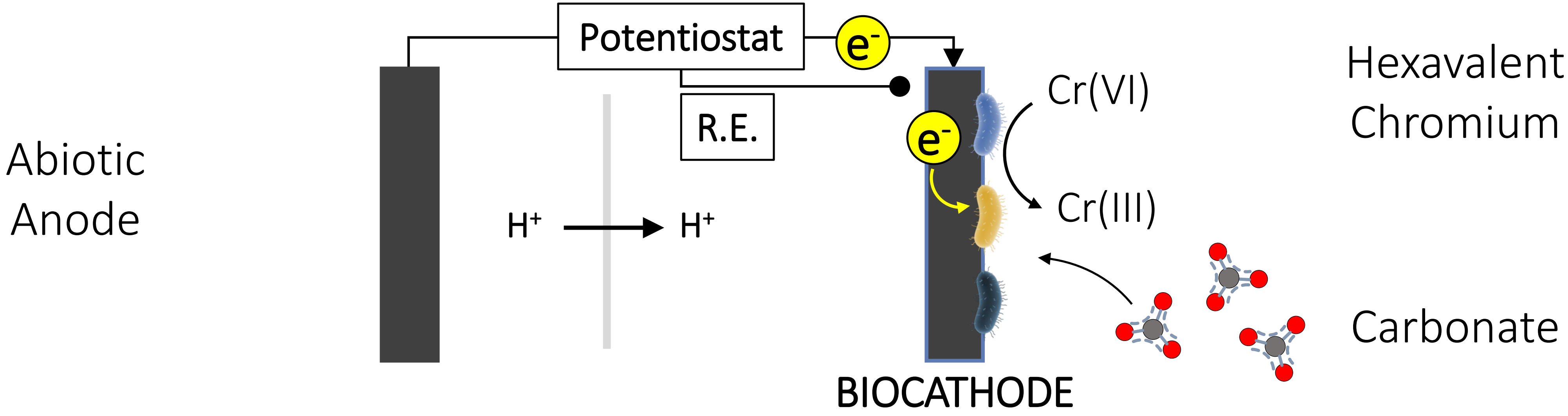
In BES applied to the removal of metals, **cathode** is used as an **electron donor** to **reduce metallic ions** present in oxidized form.

Experimental procedure

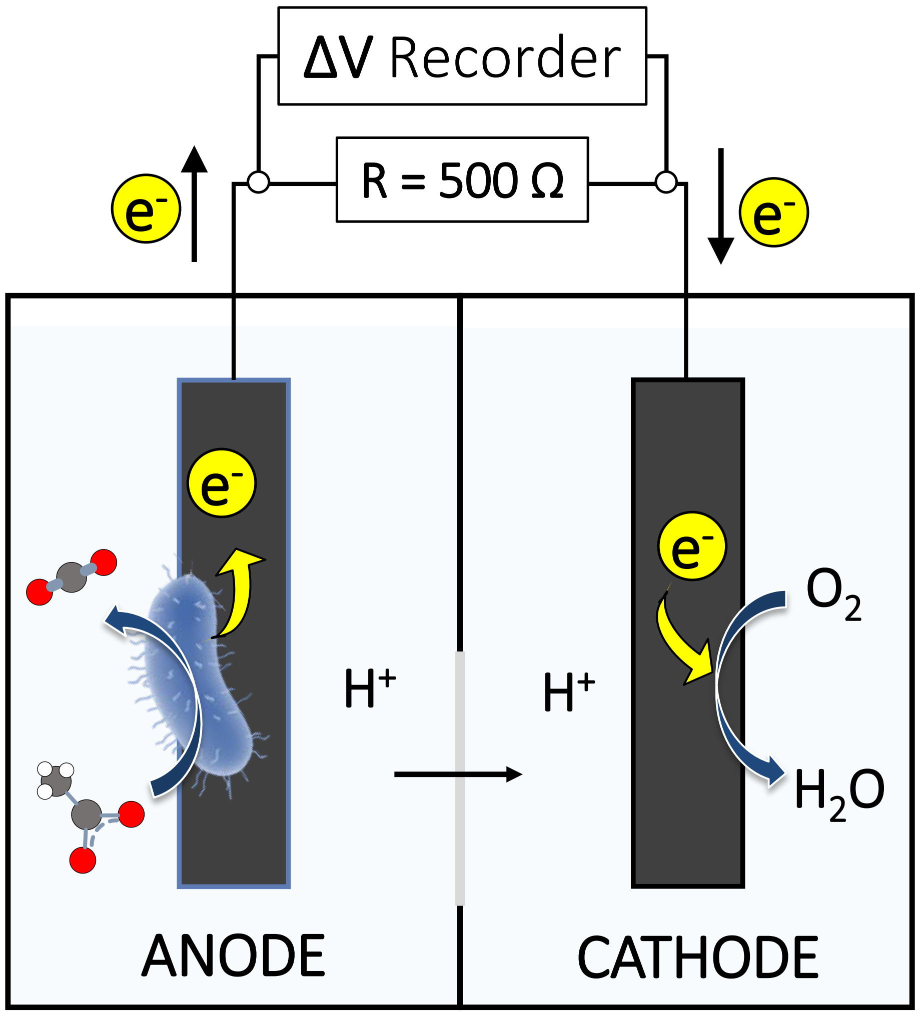
1° Step: Electroactive biofilm development in MFC



2° Step: Bioelectrochemical Cr(VI) reduction in polarized system



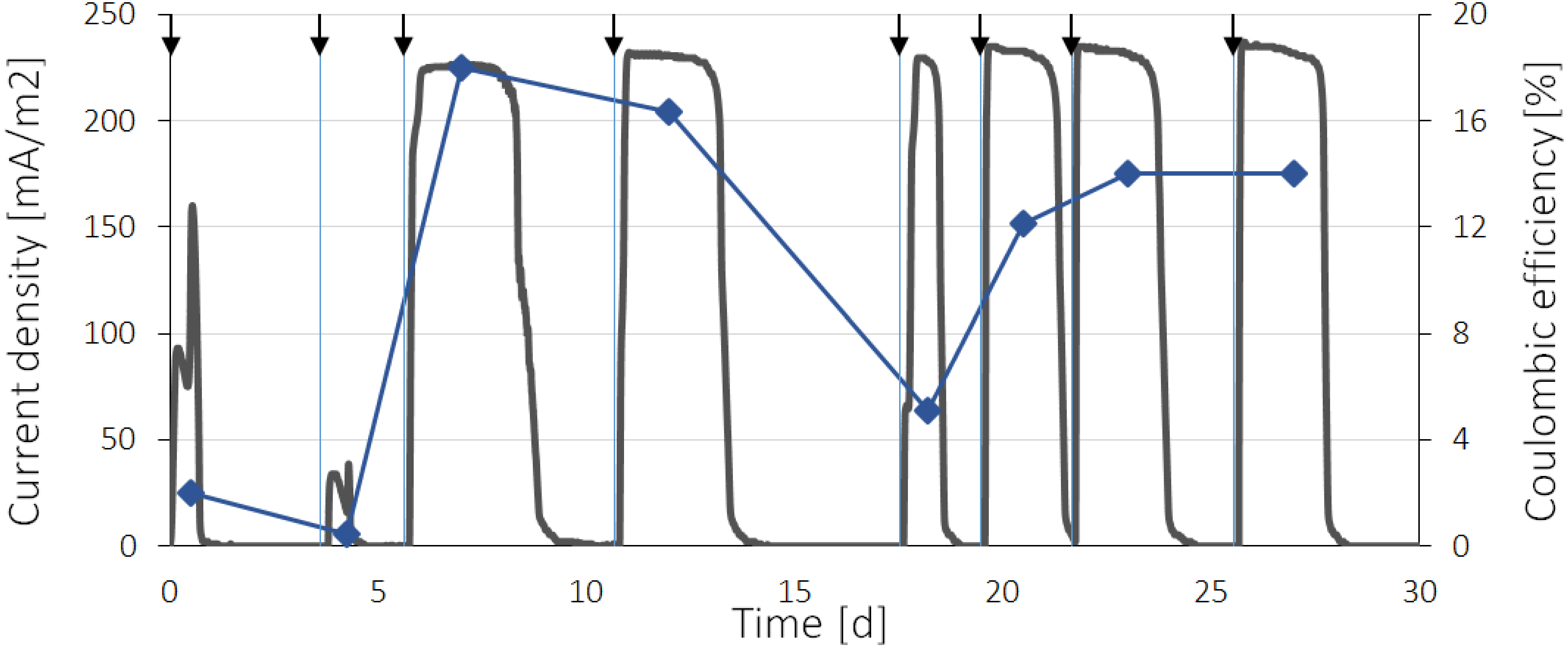
1° Step: Electroactive biofilm development in MFC



MFC Composition	
Electrode	Graphite cilinder (18,85 cm^2) linked by stainless steel cable
Substrate	Sodium Acetate (0,1 g/L)
Solution	Mineral medium
Inoculum	Anaerobic digester sludge

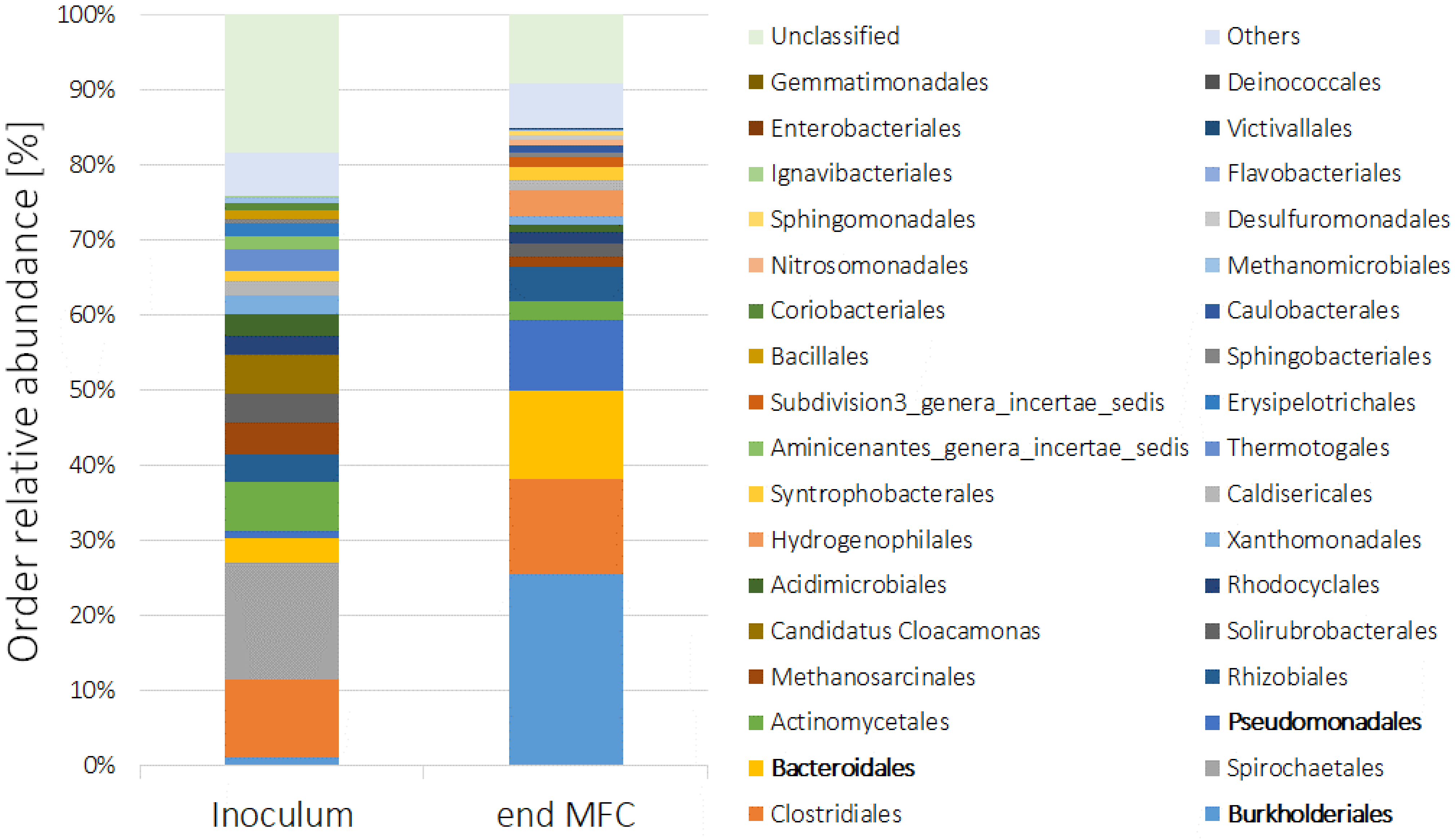
Monitoring and evaluation in MFC
Continuous recording of the circulating currents
Microbial analysis: 16S rRNA gene sequencing

Current produced by electroactive biofilm (MFC)



Current production correlated to biological oxidation of acetate → development of an *electroactive biofilm*

Characterization of the enriched microbial community in MFC



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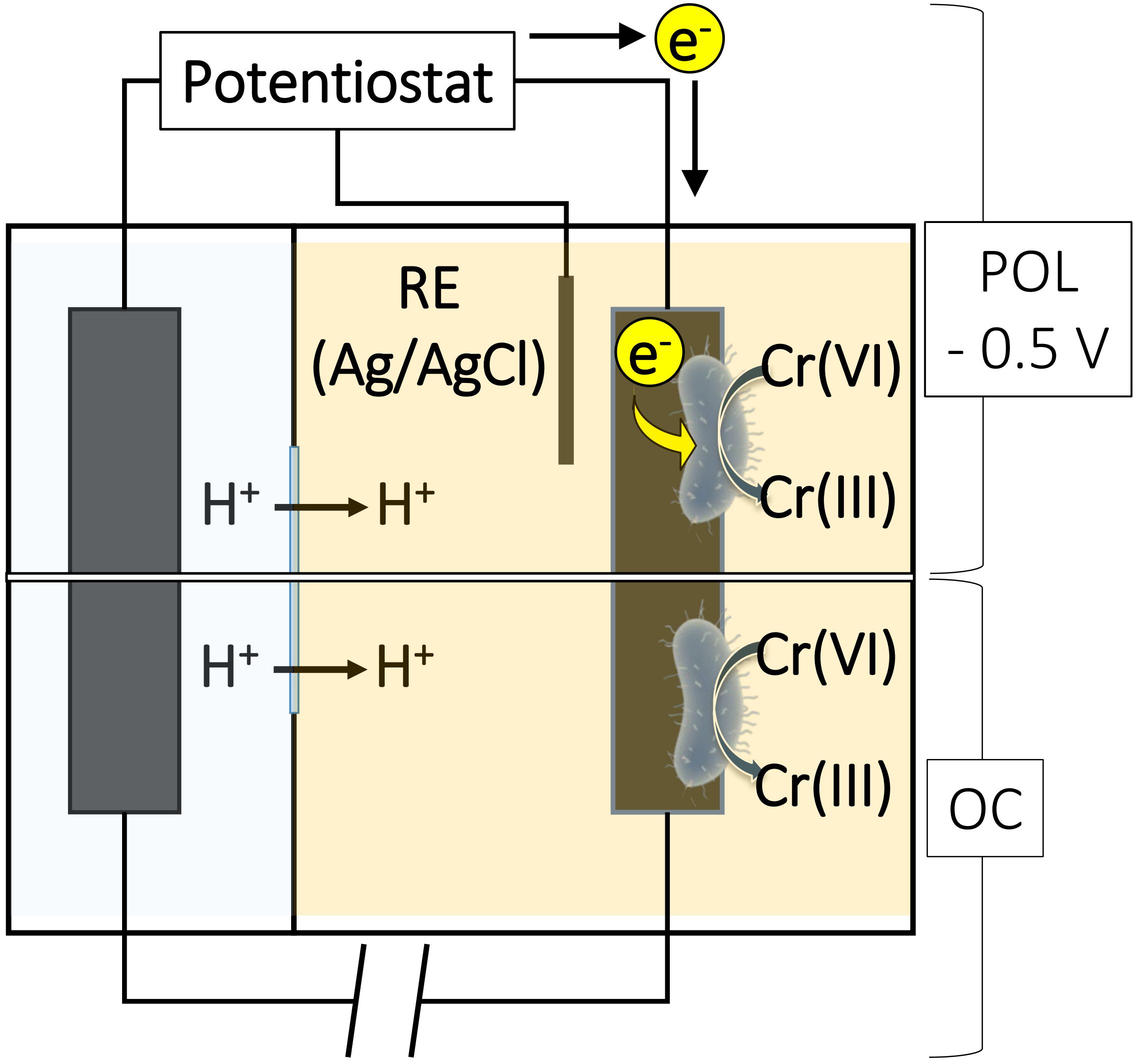
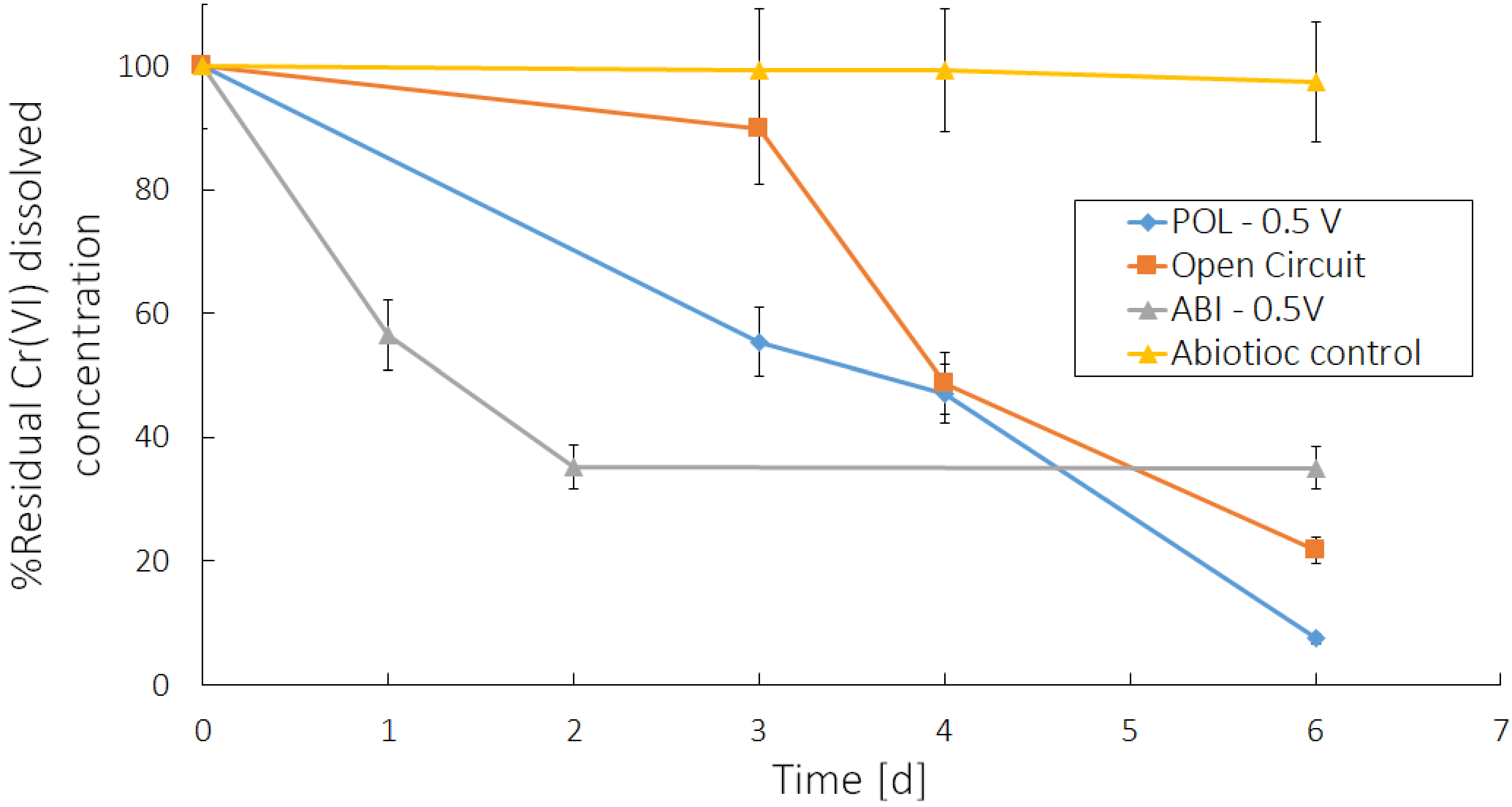


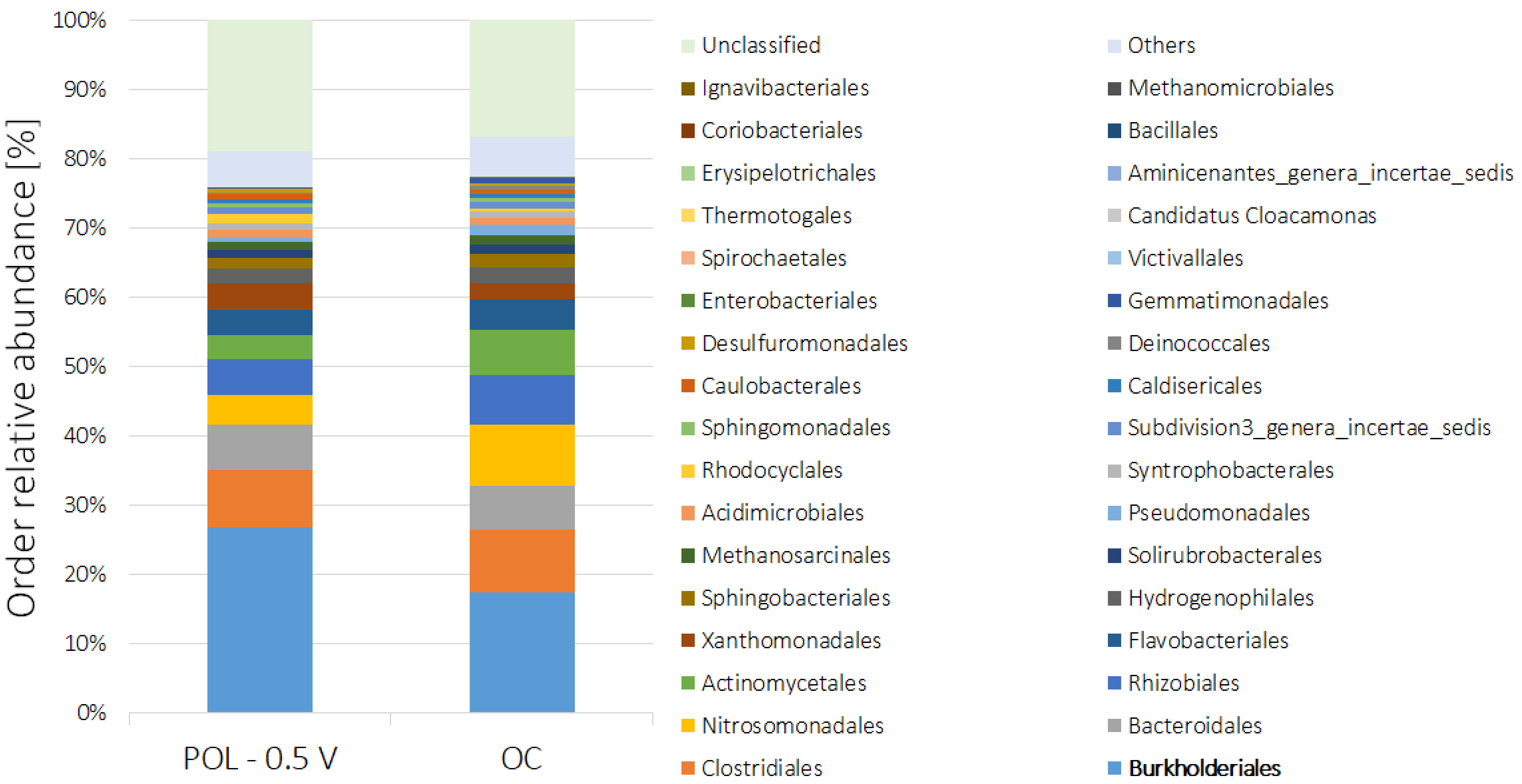
Polarized system and Control Composition	
Electrode	Cathode with electroactive biofilm
Carbonium source	HCO_3^- (g/L)
Solution	Mineral medium and inoculum (80-20% $^v/_v$)
Pollutant	Hexavalent Chromium (1 mg/L)
Sperimental condition	• Polarized system (POL - 0.5 V) • Open Circuit (OC) • Abiotic (ABI – 0.5 v)

Monitoring and evaluation
Analytical determination Cr(VI) dissolved
Microbial analysis: 16S rRNA gene sequencing

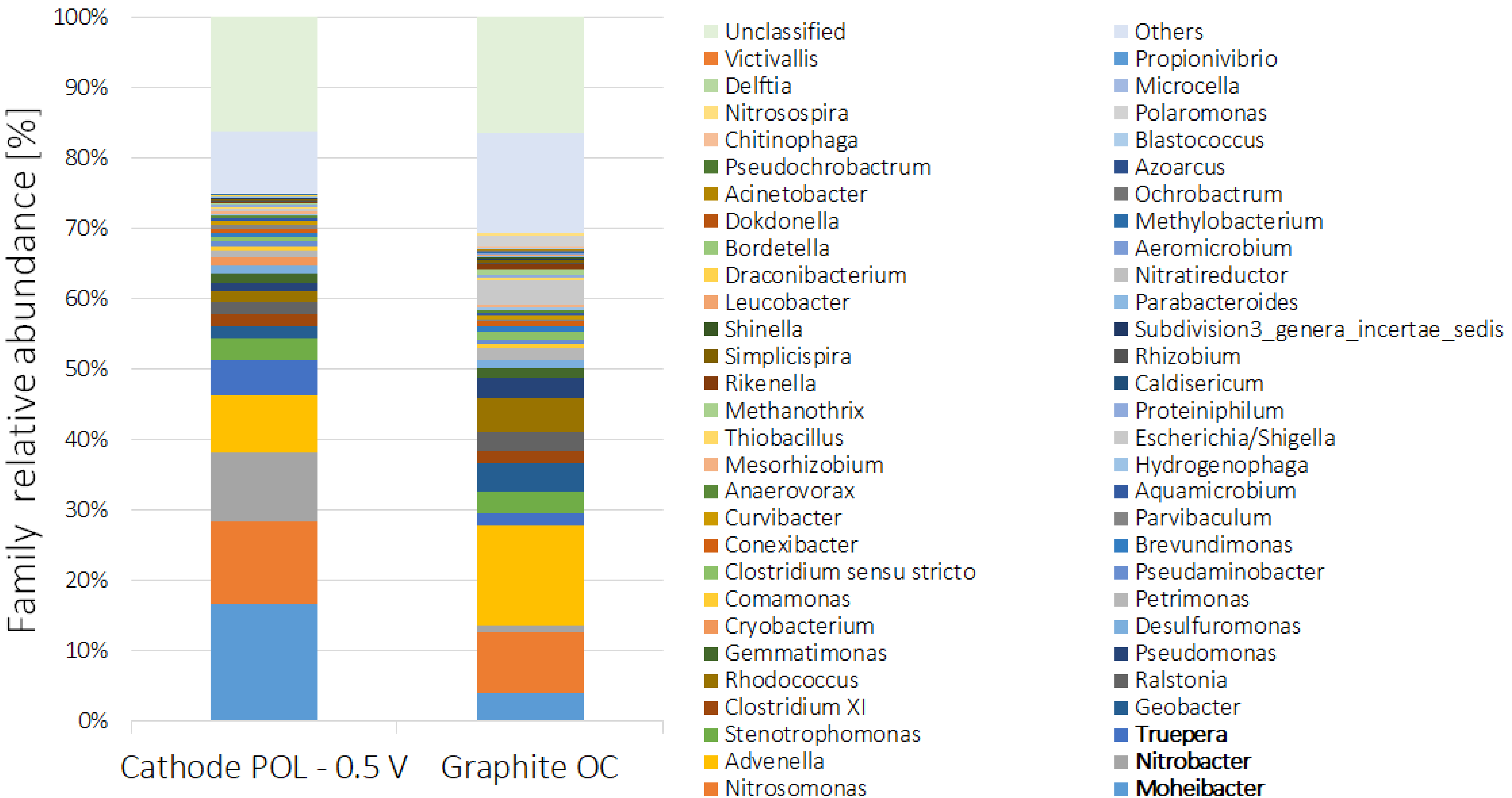
Trend of hexavalent chromium concentration



Characterization of the enriched microbial community



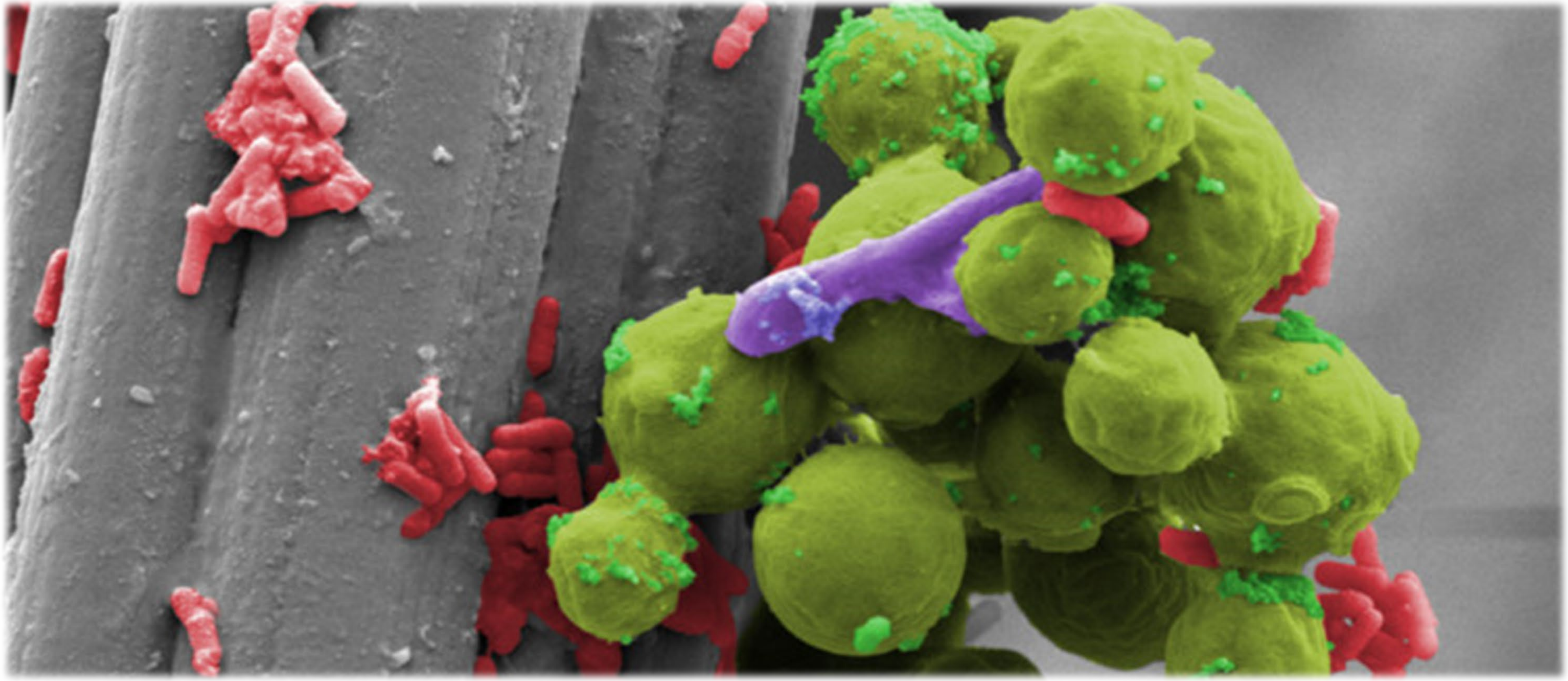
Characterization of the enriched microbial community



Conclusions

- The acclimatization phase in the MFC has made it possible to enhance the development of an electroactive biofilm.
- The **biocatode** with an imposed potential of -0.5 V (Ag / AgCl) reduced Cr(VI) dissolved in solution with a **higher efficiency** than the controls.
- The selection of the **electroactive cathodic community** has proved **essential** for the efficient removal of hexavalent chromium.
- Although **bioelectrochemical treatment** needs further studies also on a pilot scale, it can represent an **innovative** and **sustainable** approach for the removal of contaminants from groundwater.

Thank you for your attention



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