wetsus
european centre of excellence
for sustainable water technology

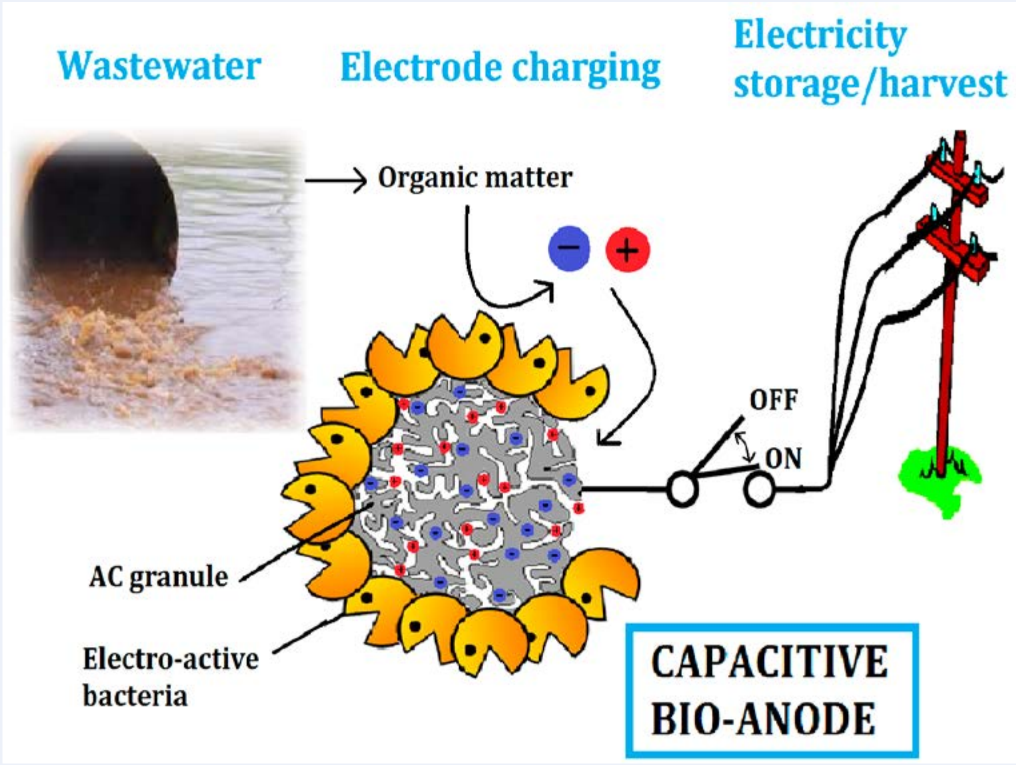
Characterization of granular activated carbon for application in bio-anodes

Leire Caizán Juanarena
leire.caizan@wur.nl

Motivation

Microbial Fuel Cells (MFCs) are devices that can use bacteria to oxidize organic matter in wastewater and produce electricity out of it [1]. Capacitive MFCs have proven to outperform non-capacitive/classical MFCs in terms of charge storage and charge recovery [2]. Specifically, the use of capacitive granular activated carbon (AC) as bio-anodes represents a cost-effective way of creating high electrode surface area and can easily be implemented in an anaerobic fluidized bed for wastewater treatment. Electrons can be stored in these granules and be released when needed in a separated discharging flat-plate cell [3].

AC granules have a conductive surface with many pores that provides large surface area for the growth of biofilms (see Figure 1a). These electrochemically active microorganisms are able to extract electrons from wastewater and store them within the capacitive granules. At the same time, protons and other cations present in the wastewater are attracted towards the granule and form an electrical double layer (EDL) to maintain electroneutrality (see Figure 1b).



Technological challenge

To study and optimize electricity production and charge storage (capacitance) in bio-anodes that combine capacitive materials, e.g. activated carbon granules (AC), with electro-active bacteria (EAB).

There are three main challenges:

- To develop a single-granule test cells and a measurement strategy to quantify capacitance and study charge-discharge behavior of AC granules.
- To find a capacitive material that allows biofilm growth with high conversion rates of organics and that has high storage capacity of electrons.
- To conceptually understand the biological charging/discharging through the development of a mathematical model.

Fig. 1a: Single AC granule with partial biofilm growth and coiled with platinum wire [4].

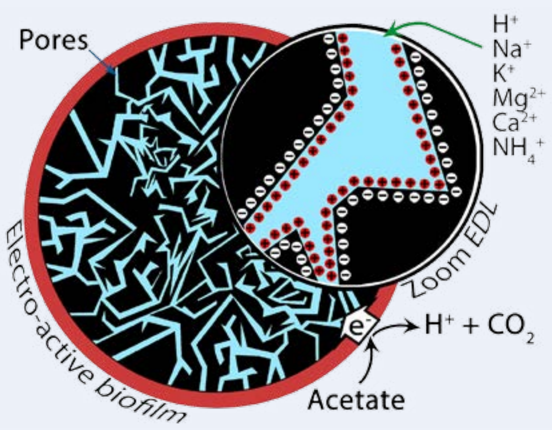


Fig. 1b: Acetate conversion and storage of electrons within AC granules via EDL formation [4].

Research goals

The present study aims to develop and study a MFC by combining an electro-active biofilm with capacitive, activated carbon granules. The main research goals are defined as following:

1. Characterization of single AC granules by its charge-discharge behaviour and quantification of its charge storage (capacitance)
2. Comparison between the capacitance of abiotic (with no microorganisms) and a biotic (with biofilm formation) AC granules
3. Development of a mathematical model that integrates bio-electrochemical and capacitive charging models
4. Study of the physical properties of granules (e.g. density, pore volume) and conditions (e.g. salt concentration, pH) that affect their capacitance

[1] R. A. Rozendal et al., *Trends Biotechnol.* (2008).
[2] A. Deeke et al., *Environ. Sci. Technol.* (2012).
[3] A. Deeke et al., *Environ. Sci. Technol.* (2015).
[4] C. Borsje et al., *submitted* (2016).

Leire Caizán Juanarena, dr. A. ter Heijne, prof.dr.ir. C.J.N. Buisman