Fouling and Process Design in reverse electrodialysis: a case study with real waters

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Motivation

To include renewable energy in the energy matrix can be a challenge for many societies. Blue energy is a promising energy source that uses the controlled mixing of the salinity gradient between river and sea water to produce energy. Reverse Electrodialysis (RED) is a process that allows to harvest this energy. It uses a series of alternating anion (AEM) and cation (CEM) exchange membranes to direct ions and convert the membrane potential between the anode and cathode of a cell into electrical current, by the means of a redox reaction. This principle is represented in Figure 1.

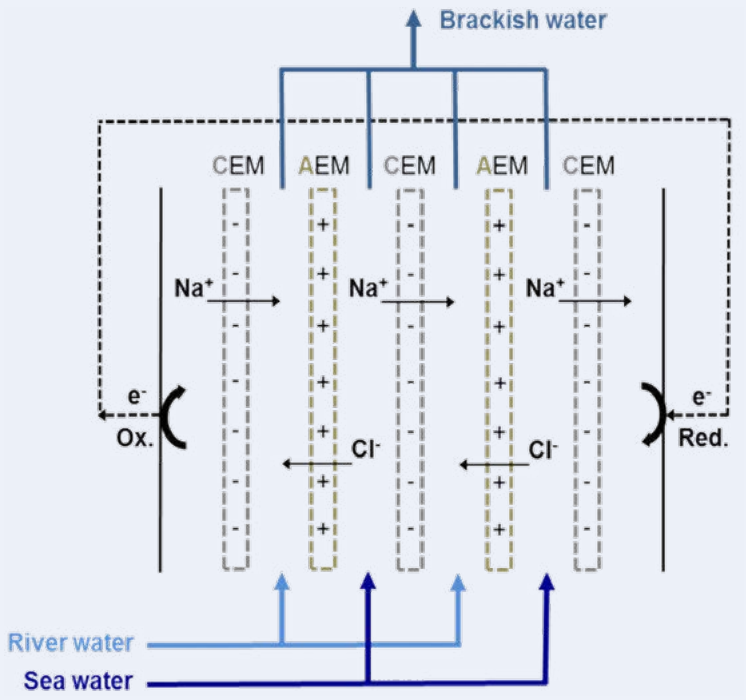

Fig 1. Simplified principle of RED.

The by-product of the process is only brackish water, so it does not generate any harmful substances to the environment. The estimated salinity gradient power available globally is estimated to be between 1.4 and 2.6 TW [1].

Technological challenge

Fouling of the ion exchange membranes is known as one of the most severe problems within RED applications, since it decreases the overall power output that can be harvested. Fouling can be present in diverse ways, like organic, inorganic, biofouling and scaling. Figure 2 shows different types of fouling.

When performing RED under natural conditions, it is important to better understand how fouling is acting on the membranes, by knowing which fouling components are present and how they interact with membranes surfaces. This can be done by using a so-called fouling monitor, allowing to visualize the evolution of fouling, as seen in Figure 3.

For a successful RED performance it is believed that a feed water pre-treatment is necessary to inhibit fouling and enable a sustainable energy production. Energetically and environmentally reasonable pre-treatment combinations will be studied. It can consist of different types of filters, like fast sand or activated carbon, or innovative treatments, like ecological filters.

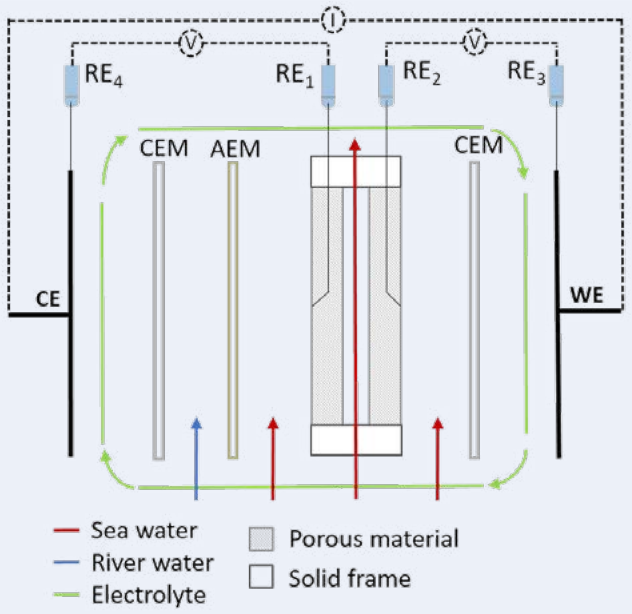

Fig 3. Schematic illustration of fouling monitor. Adapted from [3]

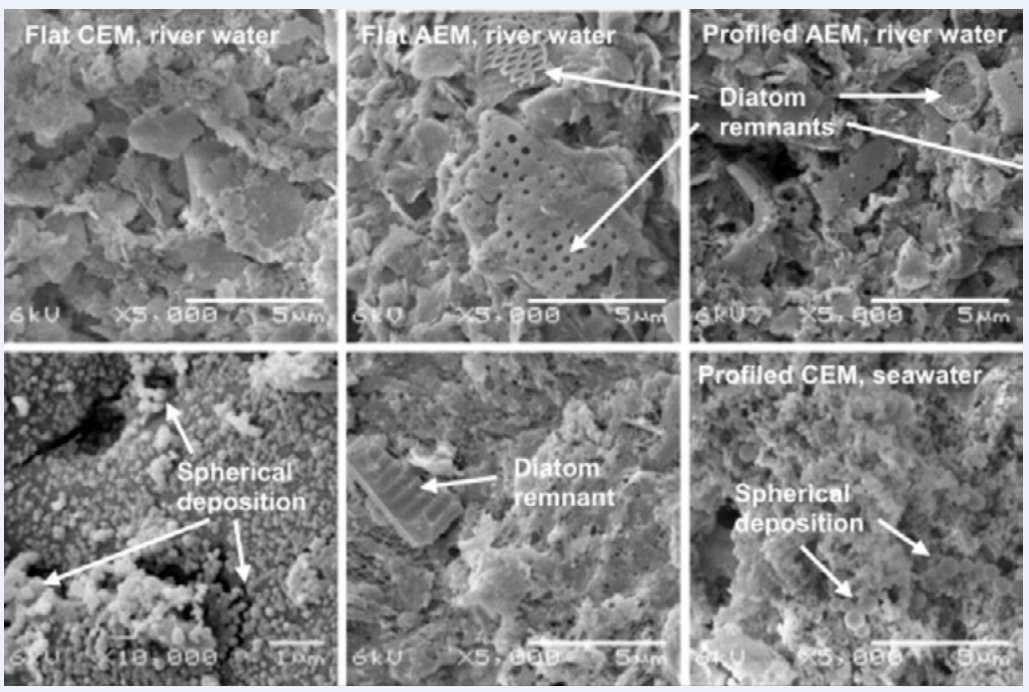

Fig 2. Fouled membranes with river and sea water, different types of AEMs and CEMs. Adapted from [2]

Research goals

The objectives of this project are:

- Identify the effect of individual foulants present in natural waters (river and sea) on RED performance,
- Identify how the foulants interact with different membranes (CEM and AEM) and how this impacts the RED process,
- Propose and test process modifications and new designs, including pre-treatment combinations and membrane cleaning.

[1] Post (2009), Blue Energy: electricity production from salinity gradients by reverse electrodialysis
[2] Vermaas et al, (2013) Water Research 47 (3), 1289-1298
[3] E. J. Bodner et al, (2019) Journal of Membrane Science 570-571, 294-302

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