# Microbial assisted electrochemical desalination: a green option for water/wastewater treatment

Wastewater discharged from industries can lead to adverse ecological effects. Commonly used conventional technologies for wastewater treatment are efficient in removing organic matter and nutrients (N and P) but less effective to reduce salinity. High salt concentrations are a major challenge that would limit the extensive use of the reclaimed water. It is also believed that inorganic components have negative impacts on the sustainability of industrial processes. Desalination of water is a promising option but the available technologies are energy and capital intensive. Alternatively, bioelectrochemical desalination process is demonstrated to be novel technology used for energy recovery, treatment and synthesis of valuable chemicals.

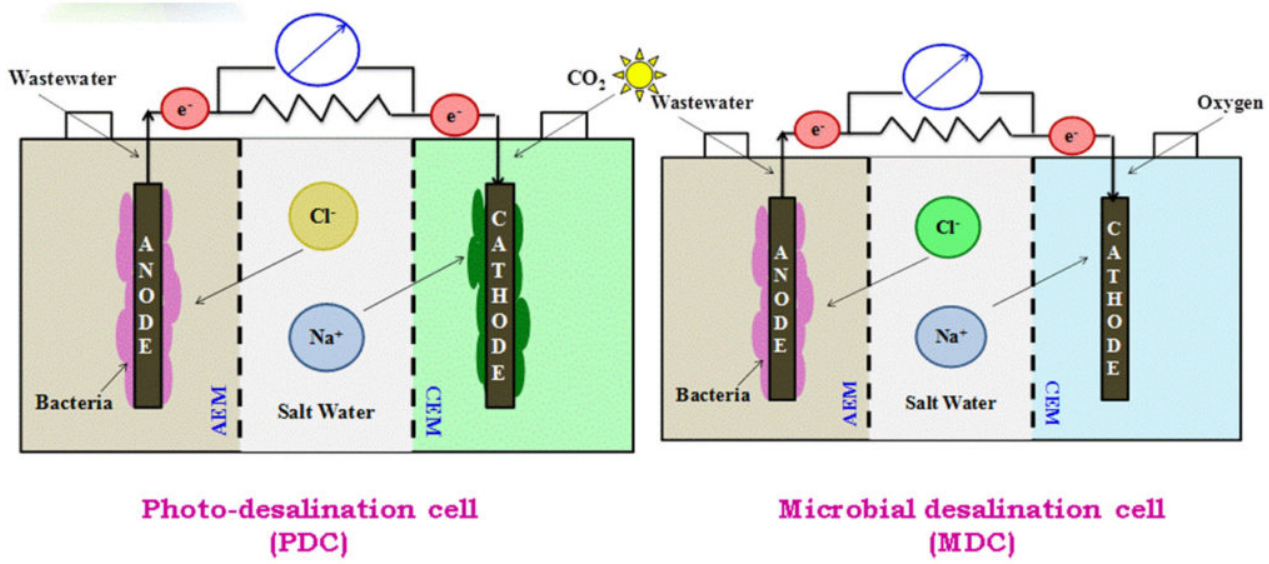


Fig. 1. Schematic representation of the mechanisms of microbial assisted desalination using abiotic and biotic cathodes.

The specific aim of the research is to comparatively assess the potential of biotic and abiotic cathodes over the combined microbial and electrochemical mechanisms in desalination and its recovery along with wastewater treatment and bioelectricity generation. This study mimics real-field conditions for desalination and investigates the complementary functions of resource recovery and wastewater treatment which are amenable for the future scalability. A close look of microbial electrochemical system (MES) for aforementioned functions highlights the importance of cathode and its reduction reaction enabling for product formation.  Besides, chemical and abiotic cathodes; recently eco-friendly biocathode that uses microbial catalyst to facilitate reduction is under investigation. Therefore, in this study a comparative assessment of abiotic and biocathode was

made using designed synthetic wastewater that simulates the real-field conditions.

In this study, a three-chambered MES was used in which the anode, middle and cathode chambers are partitioned with placement of anion and cation exchange membranes, respectively. The anaerobic bacteria in the anode compartment metabolizes the organic matter thereby generates electrons and protons which are released into solution. The AEM prevents positively charged species from leaving the anode; therefore, negatively charged species move from the middle chamber to the anode; resulting in acid formation. In the cathode, chamber electrons are consumed, resulting in positively charged species moving from the middle chamber to the cathode chamber through the CEM; resulting in alkali formation (Fig. 1). The loss of ionic species from the middle chamber results in water desalination without external application of electrical energy or water pressure. By this, the movement of ions across membranes during current generation provides a method for altering water chemistry in a manner that can be useful for achieving value-added products. Besides, algal biocathode in another set-up showed the influence of insitu oxygen generation by algae in the cathode side over the electron mobility.

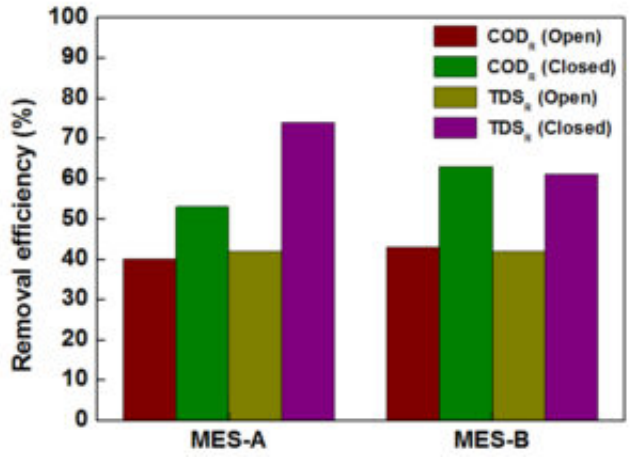


Fig. 2. Removal efficiency in microbial electrochemical systems: a) MES-A and b) MES-B in open and closed circuitry.

The maximum open voltage produced by abiotic cathode (MES-A) and biocathode (MES-B) was ?700 mV and ?600 mV, respectively. The observed disparity attributes to the enrichment of microbial diversity creating the bioelectrochemical gradient influencing the transfer efflux of ions from middle saline chamber to respective anode/cathode chambers. Further, based on the change in solution conductivity, the total dissolved salt removal was about 75% and 63% in MES-A and MES-B, respectively and the substrate removal efficiencies of MES-A and MES-B are 55% and 65%, respectively (Fig. 2). It was noticed that there was remarkable difference in solution conductivity and substrate degradation with the circuitry operation because of changes in microbial electrochemical gradient. Moreover, changes in pH at respective chambers and action of buffering

with the generation of VFA at anode were the outcomes of this research.

The criticality of MES operation lies with the cathodic electron reduction by the terminal electron acceptor (TEA). Among the many electron acceptors, oxygen is recognized as a practical due to its high reduction potential and its availability. However, the major limitation to the air cathodes is that they suffer with a disadvantage of slower redox kinetics under ambient conditions; these cathodes therefore require expensive catalyst materials (e.g. platinum) for minimizing resistance associated with oxygen reduction. Another disadvantage is related to the high-energy requirements associated with mechanical equipment used to maintain optimal dissolved oxygen concentrations in the air cathodes during scale-up. Therefore, passive methods of oxygen production using biocathodes can be a sustainable solution to address this issue. In this case, biocathodes i.e. use of mixed microalgae as biocatalysts to accept electrons provide a different path that avoids the use of chemical catalysts for oxygen reduction, thereby enhancing the economic viability and environmental sustainability of microbial desalination system and offer flexibility in producing valuable commodities. Microbial desalination carries great potential among the current desalination technologies as it is an eco-friendly process that can serve as a pre-treatment for subsequent reverse osmosis processes that significantly reduce the energy costs and membrane fouling limitations as well, cathodic product recovery at low salt concentration that makes sense for future applications.

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## Publication

Assessing potential cathodes for resource recovery through wastewater treatment and salinity removal using non-buffered microbial electrochemical systems.
Nikhil GN, Yeruva DK, Venkata Mohan S, Swamy YV
*Bioresour Technol. 2016 Sep*