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http://dx.doi.org/10.5339/qfarc.2016.EEPP3221

Microbial Desalination Cell: An Integrated Approach for Wastewater Treatment and Desalination Systems for Sustainable Water Desalination and Wastewater Treatment

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The availability of drinking water from the current available sources is decreasing due to the high demand and population increase. Seawater is a potential source for drinking water but the current desalination technology is energy intensive, therefore energy efficient desalination technology is desired. In the past decade microbial fuel cells (MFC) were emerged for simultaneous wastewater treatment and bioelectricity generation, in the anodic chamber of MFCs, microbes work as a biocatalyst to generate electrons from the oxidation of the organic compounds (wastewater) and transfer them to the anode electrode. These electrons flow through an external circuit to the cathode electrode where they used to reduce terminal electron acceptors (e.g., oxygen). Microbial desalination cells (MDC) are new potential technique for seawater desalination, in this device energy from wastewater is extracted by using microbes and without any external energy source, water desalination is driven. To convert an MFC to an MDC, a middle chamber is inserted in between the anodic and cathodic chambers of MFC using a pair of anion and cation exchange membranes. This middle chamber works as a desalination chamber in the MDC (Figure 1). The cations and anions from the desalination chamber moved to the anodic and the cathodic chambers, respectively, due to the cell potential difference between the anode electrode and the cathode electrode; as a result, salts are removed from the saltwater.

The first MDC study was reported in 2009 and since then there have been nearly 74 papers published about various aspects of MDC design and development, indicating a strong interest and rapid development of this technology. During this short period of time, various MDC designs were developed for salt removal and wastewater treatment.

Cite this article as: Sevda S, Abu Reesh IM, He Z. (2016). Microbial Desalination Cell: An Integrated Approach for Wastewater Treatment and Desalination Systems for Sustainable Water Desalination and Wastewater Treatment. Qatar Foundation Annual Research Conference Proceedings 2016: EEPP3221 http://dx.doi.org/10.5339/qfarc.2016.EEPP3221.

The desalination chamber volumes were increased from 3 ml to 105 liters and further progress is going on for salt removal and at the same time wastewater treatment. The performance of MDC was investigated using various concentrations of saline water in desalination chamber using industrial or synthetic wastewater in the anodic chamber. Different MDC designs were reviewed here. These developed new MDC designs named as air cathode MDC, stacked MDC (SMDC), up flow MDC (UMDC), recirculated MDC (RMDC), microbial electrodialysis cell (MEDC), submerged microbial desalination- denitrification cell (SMDDC), microbial capacitive desalination cell (MCDC) and osmotic microbial desalination cell (OsMDC). Different anion and cation exchange membranes were compared for power generation and desalination efficiency. This paper also reviews different substrates that have been used in MDCs so far. The MDCs provide an energy self-sustainable system in that water desalination and wastewater treatment conducted by using microbes as catalyst in the anodic chamber. Still the available MDCs were very small in volume that can't meet today's water desalination needs. In the long term operation of MDC, the membrane fouling and electrode stability are still two major problems limiting the development of MDCs. The possibility of scale-up, possible future potentials for synchrony of the MDCs with current desalination techniques were also discussed. Case study with real wastewater in the anodic chamber and real seawater in the desalination chamber were also discussed.

Acknowledgements

This work was made possible by NPRP grant # 6-289-2-125 from the Qatar National Research Fund (a member of Qatar Foundation). The statements made herein are solely the responsibility of the authors.

Reference

Sevda, S., Yuan, H., He, Z., Abu-Reesh, I.M., 2015. Microbial desalination cells as a versatile technology: Functions, optimization and prospective. Desalination 371, 9–17. doi:10.1016/j.desal.2015.05.021