Comparison of Desalination between Traditional Three Chamber Microbial Desalination Cell and Two Chamber Microbial Desalination Cell

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Abstract: In this study, rapid desalination technique was evaluated. The traditional desalination method using a three chamber microbial desalination was compared to a dual chamber microbial fuel cell in which salt solution was used as the cathode solution. Rapid desalination, with a hydraulic retention time of three hours, the dual chamber microbial fuel cell achieved 0.79 g/L/h of desalination while the traditional three chamber microbial desalination cell did not desalinate the water with the hydraulic retention time of three hours.

1. Introduction: Desalination is the process by which dissolved salts and other minerals are removed from water to make it adequate for human consumption or other activities. Brackish water, seawater, wells, surface (rivers and streams), wastewater, fracking fluids and industrial feed and process waters are some of the sources that need to be desalinated (TWDB). Desalination is a form of water recycling. Desalination technologies include; Reverse osmosis (RO), Nanofiltration (NF), Electrodialysis (ED), Forward osmosis (FO), Membrane Distillation (MD); which are both cost and energy intensive. The microbial desalination cell (MDC) is a newly-developed technology which integrates the microbial fuel cell (MFC) process and electro-dialysis for wastewater treatment, water desalination and production of renewable energy (Saeed et al., 2015). It further improves the traditional MFC by utilizing the potential gradient across the anode and cathode to drive the desalination of salt water in the middle chamber. Microbial desalination in a dual chamber microbial fuel cell is unprecedented. The cathodic solution in a traditional microbial fuel cell was replaced with saline water for direct desalination. Typical desalination rates reported are 0.0252 g/h (0.6 g/D) for stacked MDC, 2.3×10^{-3} g/h (0.055 g/D) for bio-cathode MDC with salt solution of 30-35 g/L. (Saeed, et. al., 2015)

2. Objectives: The main objective of this study was to compare the desalination rates between the three chamber microbial desalination cell and the dual chamber microbial fuel cell during the time period of initial 3 hours of reactor setup.

3. Materials and Methods: For dual chamber microbial fuel cell, the anodic solution consisted of 300 mL of bacterial growth medium sparged with Nitrogen gas, 0.5 g/L of yeast extract, 20 mL/L of used vegetable oil, and 200 mL of bacterial inoculation. The used vegetable oil was the carbon source for bacterial metabolism. The cathode consisted of a salt solution; 35 g/L NaCl. The anode and the cathode were separated by a commercial cation exchange membrane (CMI-7000). For the three chamber microbial desalination cell, the anodic solution was kept exactly similar to the dual chamber anodic solution while the middle chamber consisted of a salt solution; 35 g/L NaCl and the cathode contained deionized water with continuous supply of air. The chambers in the microbial desalination cell were bridged by a polyacrylamide polymer made in the lab. In both configurations, the anode and cathode electrodes were carbon fiber brush connected to a 1000 ohm external resistor. No electrode was used in the middle chamber of the three chamber microbial desalination cell. The working volume of each chamber was 500 mL. The pH, ORP, resistivity and conductivity of the solution was continuously monitored. The closed circuit voltage (CCV) of the system was also constantly monitored. The salt content in the solution was measured with the help of sodium ion selective electrode from Hanna Instruments. The setups are shown in Fig.1 and Fig. 2.

4. Results and Discussion: During the initial 3 hours of operation, the dual chamber microbial fuel cell produced better desalination rates than the traditional three chamber microbial desalination cell. The dual chamber microbial fuel cell achieved a desalination of 6.75 % (0.79 g/L/h) while there was zero desalination in the initial three hours. The power production in the dual chamber configuration was the highest right after setup, which gradually decreased to a voltage lower than 0.5 mV over the next couple of hours, but the rapid power production was enough to drive the desalination, while the gradually increasing voltage was not enough to drive the desalination in the three chamber microbial desalination cell.

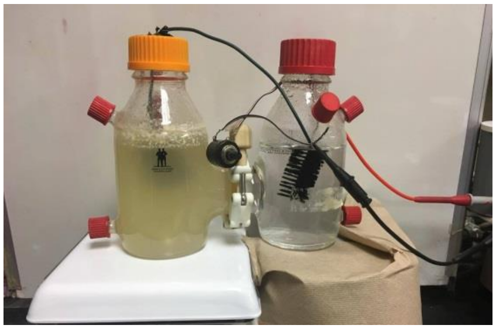

Figure 1. Experimental setup for two chamber desalination

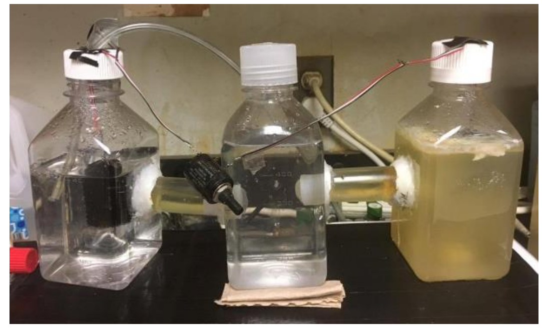

Figure 2. Experimental setup for three chamber desalination

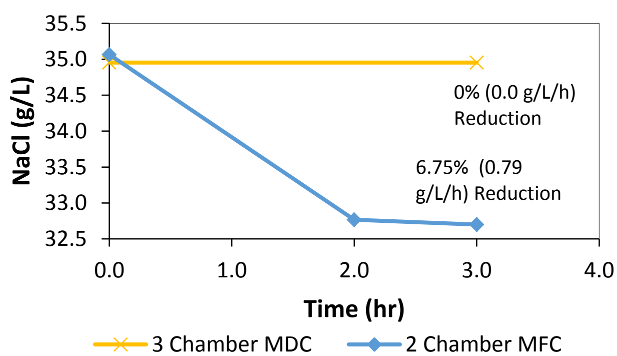

Figure 2. Change in NaCl concentration with time

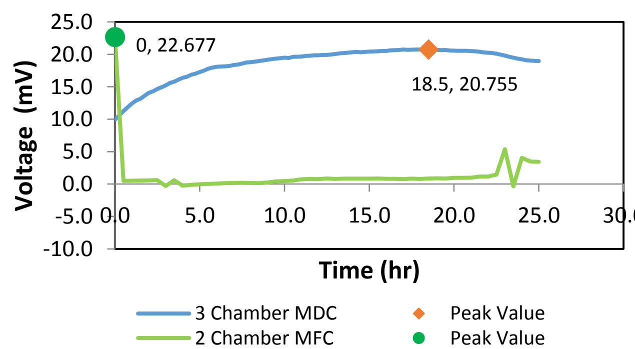

Figure 3. Voltage generation driving desalination

5. Conclusions: The results presented above show that the short term rapid desalination is achievable through the dual chamber microbial fuel cell without the added cost of membranes and extra chamber of the three chamber microbial desalination cell. Desalination in the three chamber microbial fuel cell also required higher power production than the dual chamber microbial fuel cell. A total desalination of 0.79g/L/h was achieved in the dual chamber microbial fuel cell which is a better result compared to desalination rates reported in various literature.

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7. References

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