Supporting Information

A novel multi-stage microbial desalination cell for simultaneous desalination and enhanced organics and nitrogen removal from domestic wastewater

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MATERIALS AND METHODS

Analysis and calculations. The concentration of COD, total nitrogen, and NH$_4^+$-N of wastewater were measured using colorimetric method (5B-3C, Lianhua, China). The MDC voltage ($U$) across the external resistance ($R_{ex}$) were automatically measured and recorded every 5 min using a data acquisition system (DAQ2213, ADLINK, China). Current ($I$) was determined according to Ohm’s law: $I = U/R_{ex}$. Power density ($P$) and internal resistance ($R_{in}$) were obtained from polarization curve, and the power density were calculated based on the MDC sectional area. The conductivity of the concentrate and wastewater were automatically measured and recorded every 5 min with a conductivity meter (Inlab 731, Mettler Toldeo, USA). The desalination efficiency ($DE$) in wastewater and salt recovery efficiency ($RE$) in salt water were calculated based on corresponding conductivity change as follow:

$$DE = \frac{C_{was,inf} - C_{was,eff}}{C_{was,inf}}$$ (1)

$$RE = \frac{C_{con,i} - C_{con,f}}{C_{con,i}}$$ (2)

where $C_{was,inf}$ and $C_{was,eff}$ (mS/cm) are the conductivity of wastewater influent and effluent (or effluent of each chambers) respectively, $C_{con,i}$ and $C_{con,f}$ (mS/cm) are the initial and final conductivities of the concentrate, respectively.

Coulombic efficiency ($\eta$) were utilized to evaluate the percentage of coulombs contained in wastewater to produce electricity:

$$\eta = \frac{\int I dt}{F \cdot \Delta \text{COD} \cdot Q \cdot t}$$ (3)
where $F$ is Faraday’s constant (96485 C/mol), $\Delta$COD is the COD change (g/L) of wastewater, $Q$ is the flow rate of wastewater, $t$ is operation time.

Current efficiency ($CE$) was utilized to evaluate the percentage of current being used to remove salt from wastewater ($CE_{was}$) or to recover salt in concentrate ($CE_{con}$):

$$CE_{was} = \frac{F(C_{was,inf} - C_{was,eff}) \cdot Q \cdot t}{M \cdot \int I dt}$$  \hspace{1cm} (4)

$$CE_{con} = \frac{F(C_{con,inf} - C_{con,eff}) \cdot V_{con,f}}{M \cdot \int I dt}$$  \hspace{1cm} (5)

where $M$ is the molecular weight of salt, which was regarded to be all existed in the form of NaCl ($M$: 58.5 g/mol) in this study.

Figure S1 Fabrication of the M-MDC. (A) activated carbon granules in the electrode chambers; (B) over all view of the M-MDC; (C) Titanium meshes in the electrode chambers; (D) AEM in the concentrate chamber. ACG: activated carbon granular;
CEM: cation exchange membrane; AEM: anion exchange membrane; Con: concentrate; Ww: wastewater.

Figure S2 Schematic of the M-MDC operated with AACC mode. Ww: wastewater; Con: concentrate (or concentrate chamber); ACG: activated carbon granular; Mixed IER: mixed ion exchange resins; CEM: cation exchange membrane; AEM: anion exchange membrane; AH: aeration head; An: anode; Ca: cathode.
Figure S3 The effluent quality of MDC during one concentrate replacement cycle at each HRT. (A) HRT of 4 h; (B) HRT of 8 h; (C) HRT of 12 h; (D) HRT of 16 h. Inf: influent.

Figure S4 Coulombic efficiency and current efficiency calculated based on the removed salt from wastewater and the recovered salt in concentrate.
Figure S5 Removal efficiency of TN and NH$_4^+$-N in each chamber of M-MDC at HRT of 16 h.

Figure S6 pH of wastewater in each chamber of the M-MDC during operation in ACAC mode.
**Figure S7** Effluent quality of each chamber in M-MDC when operated in AACC mode. (HRT of 64 h, adding 1.4 g/L glucose).

**Figure S8** pH of wastewater in each chamber of the M-MDC during operation in AACC mode.