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Selective ion adsorption with pilot-scale membrane capacitive deionization (MCDI): arsenic, ammonium, and manganese removal

Edgardo E. Cañas Kurz[a,b,c,*], Ulrich Hellriegel[a,b,c], Vu T. Luong[d,e], Jochen Bundschuh[f,g], Jan Hoinkis[a,f]

[a]*Center of Applied Research, Karlsruhe University of Applied Sciences, Moltkestr. 30, 76133 Karlsruhe, Germany, Tel. +49 (0)721 925 1367; email: edgardo.canas_kurz@hs-karlsruhe.de (E.E. Cañas Kurz), Tel. +49 (0)721 9251365; email: ulrich.hellriegel@hs-karlsruhe.de (U. Hellriegel), Tel. +49 (0)721 9251372; email: jan.hoinkis@hs-karlsruhe.de (J. Hoinkis)*
[b]*Laboratory of Industrial and Synthetic Organic Chemistry (LISOC), Department of Chemistry and Chemical Technologies, University of Calabria, Via Pietro Bucci 12/C, 87036 Arcavacata di Rende (CS), Italy*
[c]*Institute on Membrane Technology, National Research Council (CNR-ITM), Via Pietro Bucci 17/C, 87036 Arcavacata di Rende (CS), Italy*
[d]*Department of Mechatronics and Sensor Systems Technology, Vietnamese-German University, Le Lai Street, 822096 Binh Duong Province, Vietnam*
[e]*Department of Separation Science, School of Engineering Science, Lappeenranta-Lahti University of Technology, Sammonkatu 12, 50130 Mikkeli, Finland, Tel. +358 (0)46 6385791; email: vu.luong@lut.fi (V.T. Luong)*
[f]*School of Civil Engineering and Surveying, University of Southern Queensland, West Street, Toowoomba, 4350 Queensland, Australia, Tel. +61 7 4631 2694; email: jochenbundschuh@yahoo.com (J. Bundschuh)*
[g]*UNESCO Chair on Groundwater Arsenic within the 2030 Agenda for Sustainable Development, University of Southern Queensland, West Street, Toowoomba, 4350 Queensland, Australia*

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ABSTRACT

A pilot-scale membrane capacitive deionization (MCDI) unit was used for the selective removal of arsenic (up to 300 μg L^{-1} As(V)), ammonium (25 mg L^{-1} NH_4^+), and manganese (6 mg L^{-1} Mn^{2+}) in experiments with brackish water. Tests were carried out using a commercially available MDCI module and different initial salt concentrations (total dissolved solids, TDS = 0–2 g L^{-1} NaCl) to investigate the removal capacity and behavior of the MCDI unit with different operational parameters such as applied current, voltage, flow rate, and experimental settings such as pH. Selectivity and adsorption behavior is described and a comparison with lab-models is presented to validate the results obtained in real-life scale and application. While the adsorption capacity of the module decreased with higher TDS, specific ion adsorption improved with ionic mobility and greater ion charge. Removal of NH_4^+ and Mn^{2+} at given concentrations was significantly higher than for As(V) but rejection of As(V) could be significantly increased (30%–89.5%) by raising the initial pH value above its pK_a = 6.94. Depending on selected operational settings and feed water characteristics, the total energy consumption of the MCDI unit (only electrodes) ranged between 0.89 and 2.74 kWh m^{-3} with an overall optimum at <1 kWh m^{-3}.

Keywords: Electrosorption; Ion mobility; Groundwater remediation

* Corresponding author.