Energy usage and carbon dioxide emission saving in desalination by using desalination concentrate and wastes in microalgae production

Waddah Hussein\textsuperscript{a,b}, Maung Thein Myint\textsuperscript{c,*}, Abbas Ghassemi\textsuperscript{a,b}

\textsuperscript{a}Institute for Energy and the Environment, New Mexico State University, MSC WERC, P.O. Box 30001, Las Cruces, NM 88003, USA
\textsuperscript{b}Chemical Engineering Department, New Mexico State University, MSC ChE, P.O. Box 30001, Las Cruces, NM 88003, USA
\textsuperscript{c}Civil Engineering Department, New Mexico State University, MSC 3CE, P.O. Box 30001, Las Cruces, NM 88003, USA

Tel. +1 575 312 9300; Fax: +1 575 646 6049; email: mmyint@nmsu.edu

Received 29 August 2013; Accepted 22 December 2013

\section*{ABSTRACT}

Energy usage and CO\textsubscript{2} emission between traditional electrodialysis reversal (EDR) and innovative EDR desalinations were compared. The difference between traditional and innovative EDR desalination depended on which concentrate treatment was employed. Traditional EDR desalination consists of electrodialysis as concentrate treatment, while innovative EDR desalination consists of \textit{Dunaliella} \textit{salina} production as concentrate treatment. Microalgal species \textit{D. salina} and \textit{Arthrospira} (\textit{Spirulina}) \textit{platensis} were cultured in used bottles (3.7 L) as reactors and using desalination concentrate and supernatant from anaerobic digested sludge (SADS) as growth medium and nutrients. \textit{D. salina} was grown in reactors \textit{D}\textsubscript{1}, \textit{D}\textsubscript{2}, \textit{D}\textsubscript{3}, and \textit{D}\textsubscript{4}. \textit{Spirulina} \textit{platensis} was in \textit{S}\textsubscript{1}, \textit{S}\textsubscript{2}, \textit{S}\textsubscript{3}, and \textit{S}\textsubscript{4}. SADS was supplied to reactors \textit{D}\textsubscript{1}, \textit{D}\textsubscript{2}, \textit{S}\textsubscript{1}, and \textit{S}\textsubscript{2} as nutrient. Bold’s Basal Medium was supplied to reactors \textit{D}\textsubscript{3} and \textit{D}\textsubscript{4} while F2 was supplied to reactors \textit{S}\textsubscript{3} and \textit{S}\textsubscript{4} as nutrient. Conductivity of desalination concentrates used in reactors \textit{D}\textsubscript{1} and \textit{D}\textsubscript{3} was 31.8 and in \textit{D}\textsubscript{2} and \textit{D}\textsubscript{4} 25.4 mS/cm, respectively. Conductivity of concentrate in reactors \textit{S}\textsubscript{1} and \textit{S}\textsubscript{3} was 35.9 and in \textit{S}\textsubscript{2} and \textit{S}\textsubscript{4} 21.5 mS/cm, respectively. Dry weight concentrations of \textit{D. salina} grown in reactors \textit{D}\textsubscript{1} and \textit{D}\textsubscript{2} with SADS (1.36–1.49 g/L) were achieved which were more than that with Bold’s Basal Medium (0.84–1.04 g/L) in reactors \textit{D}\textsubscript{3} and \textit{D}\textsubscript{4} while F2 was supplied to reactors \textit{S}\textsubscript{3} and \textit{S}\textsubscript{4} as nutrient. Conductivity of concentrate in reactors \textit{S}\textsubscript{1} and \textit{S}\textsubscript{3} was 35.9 and in \textit{S}\textsubscript{2} and \textit{S}\textsubscript{4} 21.5 mS/cm, respectively. Dry weight concentrations of \textit{D. salina} grown in reactors \textit{D}\textsubscript{1} and \textit{D}\textsubscript{2} with SADS (1.36–1.49 g/L) were achieved which were more than that with Bold’s Basal Medium (0.84–1.04 g/L) in reactors \textit{D}\textsubscript{3} and \textit{D}\textsubscript{4}. Dry weight concentrations of \textit{S. platensis} with SADS (1.41–1.98 g/L) in reactors \textit{S}\textsubscript{1} and \textit{S}\textsubscript{2} were achieved which were more than that supplied with F2 (0.68–1.20 g/L) in reactors \textit{S}\textsubscript{3} and \textit{S}\textsubscript{4}. In those cases where SADS was the nutrient, low conductivity mediums provided the higher microalgae dry weight concentrations. Dry weights of both species achieved by reusing concentrate and SADS in our studies were 1.49 g/L (\textit{D. Salina}) and 1.98 g/L (\textit{S. platenis}) that are comparable to that of literature data where sea water and pretreated sea water were used. Both species gain a negative net energy ratio. Energy content of 3.02–4.24 kJ/L is required for a positive net energy ratio in microalgae growth culture. Conductivities of growth mediums from all reactors in which \textit{D. salina} were grown are less than the conductivity of drinking water quality required for sheep. Net energy ratio of \textit{D. salina} is less than that of \textit{S. platensis}. For conservative and reusable drinking water for sheep, \textit{D. salina} was used as microalgae to treat concentrate in our analyses. Energy usage and CO\textsubscript{2} emission saved from innovative integrated desalination were 4–14%.

\textit{Keywords:} CO\textsubscript{2} emission saving; Desalination concentrate; \textit{Dunaliella salina}; Energy saving; Net energy ratio; \textit{Spirulina platensis}

*Corresponding author.

1944-3994/1944-3986 © 2014 Balaban Desalination Publications. All rights reserved.