Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Supporting information

An advantage for desalination of coastal saline groundwater over seawater in view of boron removal requirements

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1. Mass transport coefficients evaluation

Three RO filtration experiments were conducted to quantify the mass transport coefficients for the water, salts, and the boron. The experiments were conducted with desalinated water, NaCl solution (EC=40 mS cm^{-1}) and SGW from Nitsanim nature reserve. For each experiment the applied pressure was varied and the permeate flux was recorded along with EC and boron concentrations when needed. Figure S1 and S2 show the results from the desalinated water and NaCl solution experiments. To retain the water permeability, the data of pressure against permeate flux was plotted and a linear regression was established. The water permeability is represented by the slope of this regression (Figure S1). For the salts and boron permeabilities and mass transfer coefficients, a simulation code was used that take the permeate flux and salt rejection (R/(1-R)) at each applied pressure and create a best fit regression and equation for the data (Figure S2). Figure S3 shows the flux relative to the applied pressures for the NaCl feed solution experiment. In addition, the same protocol was applied for the experiment with the SGW from Nitsanim nature reserve. A simulation code was used to fit the data of the permeate flux and the boron rejection (R/(1-R)) and is showed in figure S4. Furthermore, the permeate flux against the applied pressure is presented in figure S5. The coefficients are presented in Table S1.

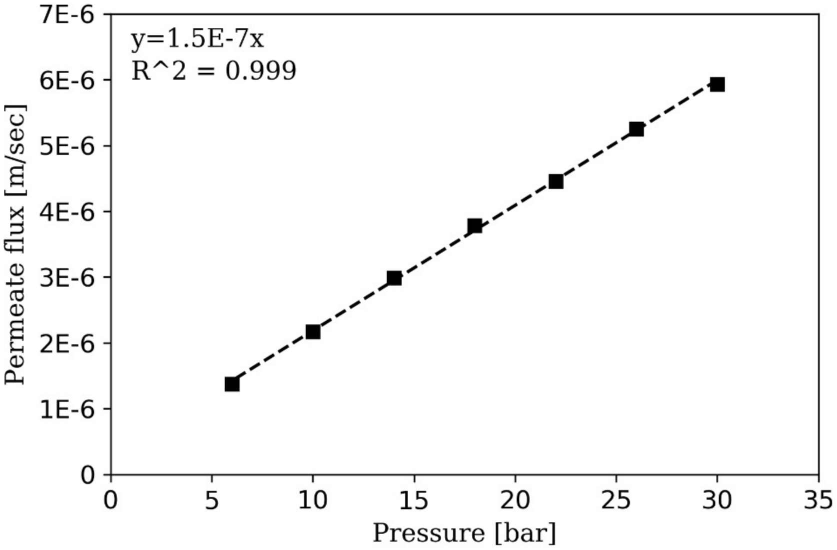

Figure S1: Permeate flux versus pressure of the desalinated water experiment. The dashed line represents the regression line.

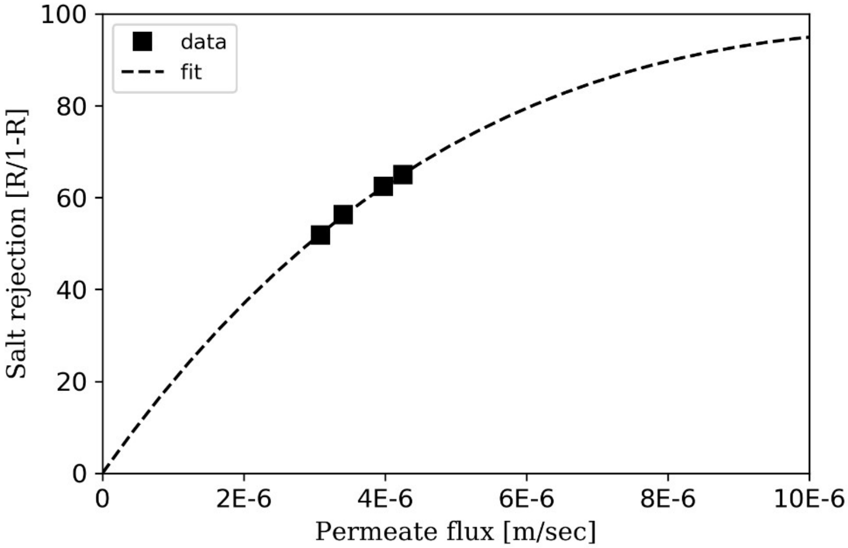

Figure S2: Best fit curve of the flux and rejection for the NaCl feed solution experiment at different applied pressures.

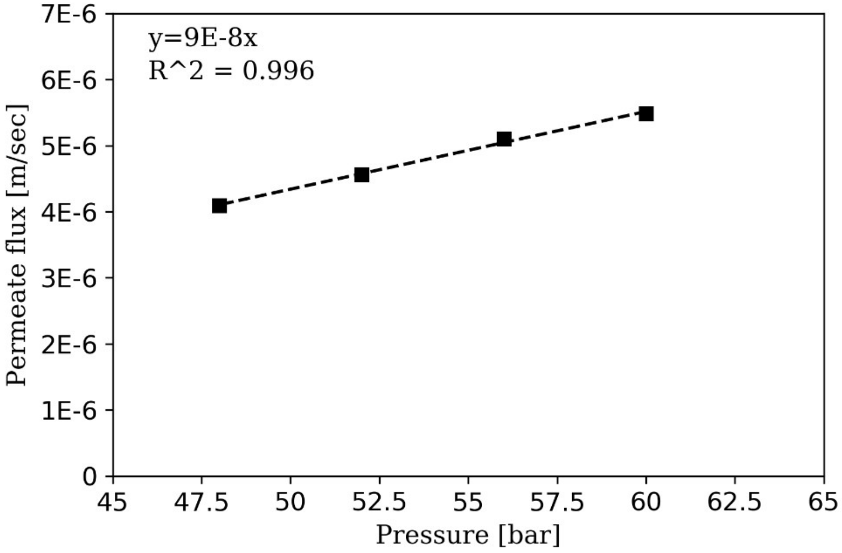

Figure S3: Permeate flux versus applied pressure of the NaCl feed solution experiment. The dashed line represents the regression line.

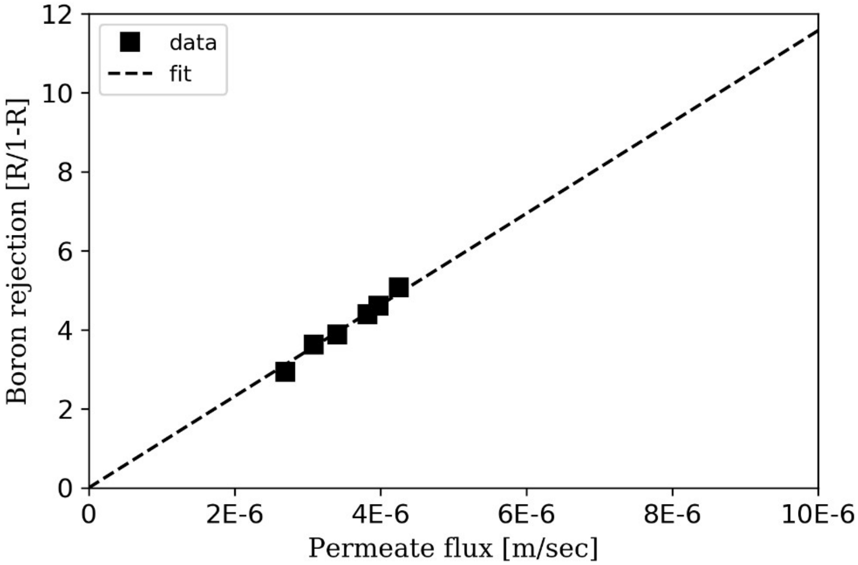

Figure S4: Best fit curve for the boron permeability and mass transport coefficient

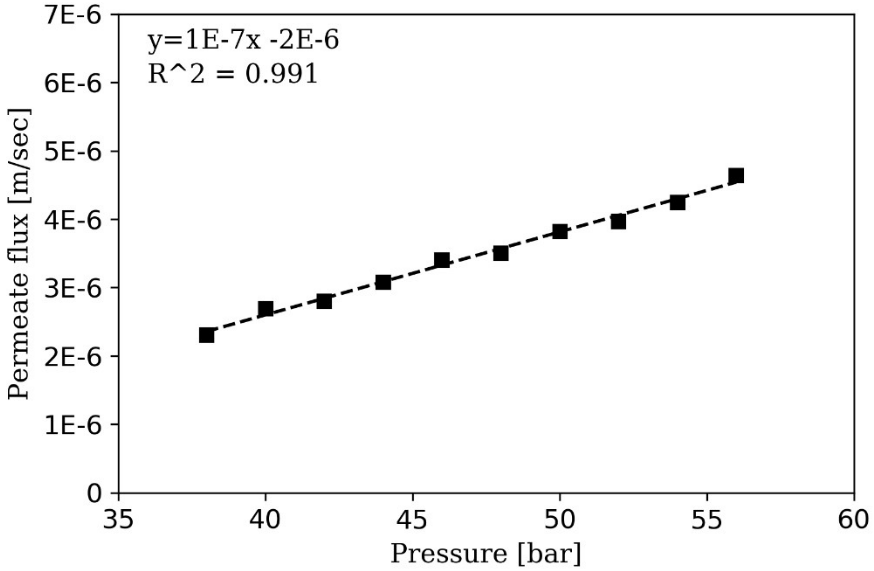

Figure S5: Permeate flux versus applied pressure of the Nitsanim SGW feed solution experiment.

The dashed line represents the regression line.

Table S1: Experimental transport parameters used as input for the WATRO model

	H_2O permeability	NaCl permeability	Mass transfer coefficient for charged solutes	B(OH)3 permeability	Mass transfer coefficient for uncharged solutes
Units	$m\ s^{-1}\ bar^{-1}$	$m\ s^{-1}$	$m\ s^{-1}$	$m\ s^{-1}$	$m\ s^{-1}$
Membrane constants	$1.5x10^{-7}$	$9x10^{-8}$	$3.22x10^{-5}$	$8.33x10^{-7}$	$3.19x10^{-5}$

Table S2: Chemical ratios of the SGW sampled for this study compared to the coastal seawater.

	SGW	Seawater	SGW/Seawater
B/Cl	0.00060	0.00064	0.9
Ca/Cl	0.06	0.04	1.8
Na/Cl	0.86	0.81	1.1
Alk/Cl	0.0066	0.0043	1.5

Table S3: Chemical analysis of SGW from three different locations along the Israeli coastal aquifer. The analysis of Nitsanim was used for this study. The units are Eq/L except of the pH and the B/Cl ratio.

	Nitsanim	Rishon-Lezion	Michmoret
Ca	0.031	0.011	0.012
Mg	0.101	0.061	0.052
Na	0.409	0.578	0.513
K	0.0082	0.0104	0.011
SO4	0.049	0.033	0.028
Br	0.00074	0.00100	0.00073
Cl	0.475	0.665	0.518
B	0.00028	0.00040	0.00038
Alkalinity	0.0031	0.0035	0.0039
TDS	1.08	1.36	1.14
pH	7.2	7.4	7.3
B/Cl	0.0006	0.0006	0.0007

2. Azomethine-H protocol for measuring boron concentrations

Measuring the total boron concentration in the water samples was conducted using the azomethine-H protocol. This method has a detection limit of 0.05 mg/L, and reproducibility of 1–2% (Vengosh et al., 1994). Boron analyses by the azomethine-H method were performed as described in (Gross et al., 2008), with slight modifications.

Plastic containers were used for this protocol. For preparing the azomethine-H solution, 0.76 g azomethine-H was added to 200 mL of DDW which was stirred using a magnetic stirrer along with 1.6 g of ascorbic acid. Ammonium acetate buffer solution was prepared by mixing 500 g ammonium acetate with 100 mL DDW and 500 mL of acetic acid. HCl solution was added until a pH of 4.8 was measured in the solution. For samples preparations, 3.5 mL of sample were pipette to a plastic test tube and 0.5 mL of 0.025 M EDTA solution was added. Next, 2.5 mL azomethine-H solution was added following 1.0 mL of the ammonium acetate buffer. The samples were left for 2 hours at room temperature for color development in dark. The absorbance was measured in the spectrophotometer at a wavelength of 420 nm. Boron concentrations were calculated based on two calibration curves, one in low salt concentrations (DDW) and the second in high salt (32 g L^{-1}), in boron range of 0.1-10 mg/L, using sodium borate.

References

Gross, A., Bernstein, A., Vulkan, R., Tarchitzky, J., Ben-Gal, A., Yermiyahu, U., 2008. Simple digestion procedure followed by the azomethine-H method for accurate boron analysis and discrimination between its fractions in wastewater and soils. Chemosphere 72, 400–406. https://doi.org/10.1016/j.chemosphere.2008.02.040

Vengosh, A., Heumann, K.G., Juraske, S., Kasher, R., 1994. Boron Isotope Application for Tracing Sources of Contamination in Groundwater. Environ. Sci. Technol. 28, 1968–1974. https://doi.org/10.1021/es00060a030