Salinity Gradient Power: Osmotic Pressure and PRO Output

Osmotic pressure of seawater and river water, the mixing energy per cubic metre of fresh water, and the best power density of pressure-retarded osmosis.

Method: Van 't Hoff osmotic pressure and pressure-retarded osmosis

Input parameters

Unit system: SI

Parameter	Value	Unit
Seawater salinity (as NaCl)	35.000	g/kg
River water salinity (as NaCl)	0.50000	g/kg
Water temperature	15.000	°C
Osmotic coefficient (about 0.93 for seawater)	0.93000	
Membrane water permeability (L per m², hour and bar)	1.5000	

Calculated results

Parameter	Value	Unit
Osmotic pressure of seawater	27.632	bar
Osmotic pressure difference	27.250	bar
Mixing energy per m³ of fresh water into much more seawater (kWh/m³)	0.75696	
Best hydraulic pressure Δπ/2	13.625	bar
Maximum PRO power density	7.7353	W/m²
Water flux at the best pressure	20.438	L/(m²·h)

Notes for this case

• Osmotic pressure π = 2φmρ_wRT for NaCl molality m. Mixing a small volume of fresh water into a large sea releases at most about Δπ per m³. PRO: W/A = A_w(Δπ − ΔP)ΔP, largest at ΔP = Δπ/2; concentration polarisation and salt leakage cut real values to about a third or less.

Formula and method

$$\pi = 2\phi m \rho_w RT, \quad \frac{W}{A} = A_w(\Delta\pi - \Delta P)\Delta P \leq \frac{A_w \Delta\pi^2}{4}$$

Variables

S_{sea}	Seawater salinity (as NaCl)	kg/kg
S_{fresh}	River water salinity (as NaCl)	kg/kg
T	Water temperature	K
ϕ	Osmotic coefficient (about 0.93 for seawater)	-
A_w	Membrane water permeability (L per m², hour and bar)	-
π_{sea}	Osmotic pressure of seawater	Pa
$\Delta\pi$	Osmotic pressure difference	Pa
E	Mixing energy per m³ of fresh water into much more seawater (kWh/m³)	-
ΔP_{opt}	Best hydraulic pressure Δπ/2	Pa
W/A	Maximum PRO power density	W/m²
J_w	Water flux at the best pressure	m/s

Method and standards

Osmotic pressure and PRO power.

Assumptions and limits

- NaCl solution; ideal-dilute van 't Hoff with an osmotic coefficient.

References

Van 't Hoff osmotic pressure and pressure-retarded osmosis

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/geothermal-ocean/salinity-gradient-osmotic-power

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.