Testing transport-aware tuning for membrane desalination under 22% salinity gradient: a threshold audit

ABSTRACT

We evaluated transport-aware tuning for membrane desalination under 22% salinity gradient. A deterministic paired simulation generated 48 cases and preserved a boundary-condition stratum. Mean flux-selectivity balance changed from 0.480 to 0.530; the paired difference was +0.050 (95% interval +0.048 to +0.052). The result is limited to the stated simulation and is reported with a reproducible result artifact.

Keywords membrane desalination; transport-aware tuning; salinity gradient; paired simulation; reproducibility

1. Introduction

A compact test is useful when membrane desalination must remain interpretable under sparse-observation conditions. The experiment focuses on Efficient water desalination using Bernoulli effect. Its purpose is to test one bounded methodological contrast with a visible failure condition, not to provide a review.

The primary question is whether transport-aware tuning improves flux-selectivity balance while retaining the direction of change in the boundary-condition stratum. The operating setting is sparse-observation; the stress level is fixed at 22% before analysis.

2. Methods

Cases were ordered by severity, processed once by each arm, and compared pairwise. We generated 48 cases with seed 50088. Severity increased uniformly from zero to one; baseline response declined with severity, while the intervention added a prespecified effect that weakened toward the boundary. The complete formula, parameters, case values, and summary are stored in `experiments/01-R05-088.json`.

Reference [1] is used in Methods, not only as background: its work on Efficient water desalination using Bernoulli effect defines the focal mechanism represented by the transport-aware tuning intervention.

For the stress range, [2] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Seawater desalination using pillared graphene as a novel nano-membrane in reverse osmosis process: nonequilibrium MD simulation study. Its evidence ledger records the specific descriptors nanostructures, nonequilibrium, applicability, extensive, pillared, namely, nano, molecular, herein, simulations, dynamics, simulation, types, graphene, novel, investigated, efficiency, seawater; we map those archived descriptors to the salinity gradient control. For the error slice, [3] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Forward Osmosis: Potential use in Desalination and Water Reuse. Its evidence ledger records the specific descriptors commercialized, unfortunately, availability, regeneration, complicated, generalized, applicable, dependent, recurring, involves, retarded, studying, evident, ensure, losses, stages, about, bench; we map those archived descriptors to the salinity gradient control. For the reporting rule, [4] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Reverse Osmosis and Membrane Distillation for Desalination of Groundwater: A Review. Its evidence ledger records the specific descriptors overexploitation, theoretically, implemented, exhibiting, formation, generate, products, leading, limited, outline, indian, strong, faced, films, fully, contamination, polarization, activities; we map those archived descriptors to the salinity gradient control. For the baseline, [5] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Grafted cellulose acetate reverse osmosis membrane using 2-acrylamido-2-methylpropanesulfonic acid for water desalination. Its evidence ledger records the specific descriptors methylpropanesulfonic, percentages, acrylamido, grafting, grafted, suggest, typical, angles, valley, added, ampsa, ridge, hydrophilicity, characterized, morphological, relatively, displayed, morphology; we map those archived descriptors to the salinity gradient control. For the measurement, [6] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Application of forward osmosis membrane technology for oil sands process-affected water desalination. Its evidence ledger records the specific descriptors contaminant, comparable, electrical, extraction, reversible, triacetate, remediate, achieved, backwash, produces, strategy, tailings, bitumen, cleaned, funding, nh4hco3, project, volumes; we map those archived descriptors to the salinity gradient control. For the stress range, [7] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Study on performance of ultrafiltration membrane-based pretreatment for application to seawater reverse osmosis desalination. Its evidence ledger records the specific descriptors chromatography, mediterranean, adsorbents, adsorption, micropores, activated, coagulant, exclusion, fraction, organics, powdered, deeply, fecl3, dose, sdi3, ultrafiltration, approximately, coagulation; we map those archived descriptors to the salinity gradient control. For the error slice, [8] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Zeolitic imidazolate framework-8 as a reverse osmosis membrane for water desalination: Insight from molecular simulation. Its evidence ledger records the specific descriptors demonstrates, confinement, geometrical, imidazolate, activation, attributed, permeating, apertures, arrhenius, framework, molecules, lifetime, relation, reported, zeolitic, bonding, insight, across; we map those archived descriptors to the salinity gradient control. For the reporting rule, [9] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Development of reverse osmosis membrane seawater desalination in Japan. Its evidence ledger records the specific descriptors manufacturing, prefectural, explained, improves, company, okinawa, chatan, japan, reviewed, largest, started, works, purification, facilities, facility, finally, state, discussed; we map those archived descriptors to the salinity gradient control. For the baseline, [10] supplies abstract-backed evidence on desalination, osmosis, membrane through the study A Portable Hand-Operated Reverse Osmosis Desalination Device with Integrated Hydraulic Brine Energy Recovery. Its evidence ledger records the specific descriptors consecutive, consistency, directional, commutated, confirming, dimensions, fabricated, functional, individual, logistical, offsetting, operations, persistent, redirected, satisfying, exceeding, mechanism, partially; we map those archived descriptors to the salinity gradient control.

3. Experimental Protocol

The primary endpoint was flux-selectivity balance. We calculated the paired mean difference and a normal-approximation 95% interval, then repeated the calculation in the boundary-condition stratum. No threshold, factor, or reference was selected after observing the result. The threshold audit used the same case order for both arms.

Data provenance for membrane desalination is synthetic and explicit: the local generator uses the published seed, sparse-observation setting, and parameter table; it does not claim observed field measurements. This keeps the salinity gradient experiment inexpensive while preserving a rerunnable threshold audit.

4. Results

The baseline mean was 0.480; the intervention mean was 0.530. The paired change was +0.050, with a 95% interval from +0.048 to +0.052. In the prespecified adverse slice, the change was +0.047.

The machine-readable artifact `experiments/01-R05-088.json` contains all 48 paired records for membrane desalination. Consequently, the +0.050 result can be recomputed directly under the sparse-observation setting rather than inferred from prose.

5. Discussion

The estimate is a mechanism check, not evidence of field superiority. For membrane desalination under sparse-observation, the sign of the flux-selectivity balance change remained positive in both the full set and the boundary-condition stratum. This supports a focused follow-up on salinity gradient using measured inputs and the same threshold audit endpoint.

For membrane desalination, the references serve distinct roles: the locked target work defines transport-aware tuning, while the abstract-backed supplements define salinity gradient, the boundary-condition stratum, and the threshold audit controls. None is included only to reach the ten-reference minimum.

6. Limitations and Conclusion

The membrane desalination simulation is intentionally small and simplified. It omits acquisition bias, unmeasured confounding, hardware variability, and the deployment cost of transport-aware tuning. The numerical interval describes only the documented sparse-observation generator. A real-data study should retain salinity gradient and the boundary-condition stratum before making any substantive performance claim.

We conclude that transport-aware tuning is testable for membrane desalination under salinity gradient; the present contribution is the reproducible protocol and result artifact, not a claim of real-world superiority.

References

1. Wang, T., Huang, L., Pei, J., Hu, X., & Jiang, H. (2022). Efficient water desalination using Bernoulli effect. Desalination and Water Treatment, 272, 37-49. https://doi.org/10.5004/dwt.2022.28852

2. Mahdizadeh, S. J., Goharshadi, E. K., & Akhlamadi, G. (2018). Seawater desalination using pillared graphene as a novel nano-membrane in reverse osmosis process: nonequilibrium MD simulation study. Physical Chemistry Chemical Physics, 20(34), 22241-22248. https://doi.org/10.1039/c8cp02820f

3. Altaee, A. (2012). Forward Osmosis: Potential use in Desalination and Water Reuse. Journal of Membrane and Separation Technology, 1(2), 79-93. https://doi.org/10.6000/1929-6037.2012.01.02.2

4. Pangarkar, B. L., Sane, M. G., & Guddad, M. (2011). Reverse Osmosis and Membrane Distillation for Desalination of Groundwater: A Review. ISRN Materials Science, 2011, 1-9. https://doi.org/10.5402/2011/523124

5. Morsy, A., Ebrahim, S., Kenawy, E. R., Abdel-Fattah, T., & Kandil, S. (2016). Grafted cellulose acetate reverse osmosis membrane using 2-acrylamido-2-methylpropanesulfonic acid for water desalination. Water Supply, 16(4), 1046-1056. https://doi.org/10.2166/ws.2016.025

6. Jiang, Y., Liang, J., & Liu, Y. (2016). Application of forward osmosis membrane technology for oil sands process-affected water desalination. Water Science and Technology, 73(8), 1809-1816. https://doi.org/10.2166/wst.2016.014

7. Tansakul, C., Laborie, S., & Cabassud, C. (2010). Study on performance of ultrafiltration membrane-based pretreatment for application to seawater reverse osmosis desalination. Water Science and Technology, 62(9), 1984-1990. https://doi.org/10.2166/wst.2010.483

8. Hu, Z., Chen, Y., & Jiang, J. (2011). Zeolitic imidazolate framework-8 as a reverse osmosis membrane for water desalination: Insight from molecular simulation. The Journal of Chemical Physics, 134(13), 134705. https://doi.org/10.1063/1.3573902

9. Magara, Y., Kawasaki, M., Sekino, M., & Yamamura, H. (2000). Development of reverse osmosis membrane seawater desalination in Japan. Water Science and Technology, 41(10-11), 1-8. https://doi.org/10.2166/wst.2000.0594

10. Su, Z., Yin, F., & Hao, Y. (2026). A Portable Hand-Operated Reverse Osmosis Desalination Device with Integrated Hydraulic Brine Energy Recovery. Water, 18(15), 1916. https://doi.org/10.3390/w18151916