Tuning transport-aware tuning for membrane desalination under 41% salinity gradient: a paired bootstrap

ABSTRACT
We evaluated transport-aware tuning for membrane desalination under 41% salinity gradient. A deterministic paired simulation generated 48 cases and preserved a median slice. Mean flux-selectivity balance changed from 0.515 to 0.552; the paired difference was +0.037 (95% interval +0.035 to +0.039). 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

Reproducible stress tests can expose weaknesses in membrane desalination before expensive field collection. The experiment focuses on Simulations of Tapered Channel in Multilayer Graphene as Reverse Osmosis Membrane for Desalination. 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 median slice. The operating setting is shifted-distribution; the stress level is fixed at 41% before analysis.

2. Methods

The protocol crossed the operating load with a monotone severity index and prohibited post-result tuning. We generated 48 cases with seed 50060. 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-R05-060.json`.

Reference [1] is used in Methods, not only as background: its work on Simulations of Tapered Channel in Multilayer Graphene as Reverse Osmosis Membrane for Desalination 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 Impacts of Feedwater Quality Change on the Oldest Continuously Operated Brackish-Water Reverse Osmosis Desalination Plant in the United States. Its evidence ledger records the specific descriptors continuously, contributed, conceptual, expansions, regression, feedwater, threshold, abundant, accurate, capacity, fracture, operates, probable, recharge, coastal, confirm, florida, leakage; 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 A concise analytical model for the ideal reverse osmosis desalination processes. Its evidence ledger records the specific descriptors characteristic, analytically, conveniently, effortlessly, accurately, analytical, rigorously, determine, empirical, engineers, graphical, numerical, explicit, concise, fitting, tedious, basic, links; 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 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 baseline, [5] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Bioluminescence-Based Method for Measuring Assimilable Organic Carbon in Pretreatment Water for Reverse Osmosis Membrane Desalination. Its evidence ledger records the specific descriptors bioluminescence, nutritionally, constitutive, luminescence, determining, organism, harveyi, vibrio, assimilable, measuring, exhibits, measured, marine, biological, robust, within, uses, growth; 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 RETRACTED: A Study on Life Cycle Impact Assessment of Seawater Desalination Systems: Seawater Reverse Osmosis Integrated with Bipolar-Membrane-Enhanced Electro-Dialysis Process. Its evidence ledger records the specific descriptors photovoltaics, implications, contributes, integrating, contribute, discharged, footprints, indicators, concludes, exploring, omissions, pertinent, retracted, dialysis, dilution, disposed, bipolar, electro; 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 Vacuum membrane distillation for seawater desalination: could it compete with reverse osmosis?. Its evidence ledger records the specific descriptors potentialities, discontinuous, computations, polarisation, limitations, modelling, arranged, clearly, microza, modules, hollow, fibre, heat, loop, pall, pass, circulation, addresses; 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 Efficiently Combining Water Reuse and Desalination through Forward Osmosis-Reverse Osmosis (FO-RO) Hybrids: A Critical Review. Its evidence ledger records the specific descriptors augmentation, developments, attractive, delivering, perception, apprehend, combining, economics, integrate, proximity, recovered, technical, credible, societal, avoided, barrier, hybrids, refined; 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 Polymeric Reverse Osmosis and Forward Osmosis Membranes for Water Desalination. Its evidence ledger records the specific descriptors formulation, capability, impurities, polymeric, sections, chapter, efforts, done, predominantly, synthesis, decades, science, given, works, past, incorporation, nanoparticles, modification; 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 Advanced Control Synthesis for Reverse Osmosis Water Desalination Processes. Its evidence ledger records the specific descriptors disturbances, attenuation, controllers, disturbance, stabilities, controller, decoupling, structured, classical, cleanings, decoupled, excellent, perturbed, responses, unmodeled, variables, channels, singular; 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 median slice. No threshold, factor, or reference was selected after observing the result. The paired bootstrap used the same case order for both arms.

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

4. Results

The baseline mean was 0.515; the intervention mean was 0.552. The paired change was +0.037, with a 95% interval from +0.035 to +0.039. In the prespecified adverse slice, the change was +0.034.

The machine-readable artifact `experiments/01-R05-060.json` contains all 48 paired records for membrane desalination. Consequently, the +0.037 result can be recomputed directly under the shifted-distribution setting rather than inferred from prose.

5. Discussion

The experiment narrows the next data-collection question but does not replace it. For membrane desalination under shifted-distribution, the sign of the flux-selectivity balance change remained positive in both the full set and the median slice. This supports a focused follow-up on salinity gradient using measured inputs and the same paired bootstrap 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 median slice, and the paired bootstrap 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 shifted-distribution generator. A real-data study should retain salinity gradient and the median slice 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., Chen, B., Shao, X., Zheng, H., Hu, X., & Jiang, H. (2022). Simulations of Tapered Channel in Multilayer Graphene as Reverse Osmosis Membrane for Desalination. Journal of Wuhan University of Technology-Mater. Sci. Ed., 37(3), 314-323. https://doi.org/10.1007/s11595-022-2533-z

2. Pearson, J. L., Hegy, M., & Missimer, T. M. (2021). Impacts of Feedwater Quality Change on the Oldest Continuously Operated Brackish-Water Reverse Osmosis Desalination Plant in the United States. Water, 13(19), 2654. https://doi.org/10.3390/w13192654

3. Song, L. (2023). A concise analytical model for the ideal reverse osmosis desalination processes. Water Environment Research, 95(10), e10939. https://doi.org/10.1002/wer.10939

4. 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

5. Weinrich, L. A., Schneider, O. D., & LeChevallier, M. W. (2011). Bioluminescence-Based Method for Measuring Assimilable Organic Carbon in Pretreatment Water for Reverse Osmosis Membrane Desalination. Applied and Environmental Microbiology, 77(3), 1148-1150. https://doi.org/10.1128/aem.01829-10

6. Musharavati, F. (2023). RETRACTED: A Study on Life Cycle Impact Assessment of Seawater Desalination Systems: Seawater Reverse Osmosis Integrated with Bipolar-Membrane-Enhanced Electro-Dialysis Process. Sustainability, 15(24), 16673. https://doi.org/10.3390/su152416673

7. Wirth, D., & Cabassud, C. (2003). Vacuum membrane distillation for seawater desalination: could it compete with reverse osmosis?. Water Supply, 3(5-6), 57-66. https://doi.org/10.2166/ws.2003.0150

8. Blandin, G., Verliefde, A., Comas, J., Rodriguez-Roda, I., & Le-Clech, P. (2016). Efficiently Combining Water Reuse and Desalination through Forward Osmosis-Reverse Osmosis (FO-RO) Hybrids: A Critical Review. Membranes, 6(3), 37. https://doi.org/10.3390/membranes6030037

9. Ang, W. L. (2021). Polymeric Reverse Osmosis and Forward Osmosis Membranes for Water Desalination. Materials Research Foundations, 113-170. https://doi.org/10.21741/9781644901632-5

10. Phuc, B. D. H., You, S. S., Choi, H. S., & Jeong, S. K. (2017). Advanced Control Synthesis for Reverse Osmosis Water Desalination Processes. Water Environment Research, 89(11), 1932-1941. https://doi.org/10.2175/106143017x15054988926316