Auditing transport-aware tuning for membrane desalination under 48% salinity gradient: a error-stratified estimate

ABSTRACT
We evaluated transport-aware tuning for membrane desalination under 48% salinity gradient. A deterministic paired simulation generated 72 cases and preserved a boundary-condition stratum. Mean flux-selectivity balance changed from 0.583 to 0.628; the paired difference was +0.045 (95% interval +0.043 to +0.047). 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

The design begins from a narrow failure mode in membrane desalination rather than a broad literature survey. 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 mixed-load; the stress level is fixed at 48% before analysis.

2. Methods

We used a deterministic severity sweep and retained identical noise draws for the primary contrast. We generated 72 cases with seed 50147. 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-R05-147.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 Multi-dimensional parametric study for enhancing Brackish Water Reverse Osmosis membrane performance suited for desalination of low salinity feeds. Its evidence ledger records the specific descriptors dimethylformamide, concurrently, alterations, dimensional, structuring, introduces, treatments, alongside, including, unaltered, enhances, glycerol, swelling, tailored, broader, capable, context, desired; 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 Innovative Nanostructured Membranes for Reverse Osmosis Water Desalination. Its evidence ledger records the specific descriptors allylaminehydrochloride, polyelectrolytes, montmorillonite, investigations, nanostructured, nanoparticle, vinylsulfate, established, fabrication, manufacture, polysulfone, experience, overcoming, recognized, alternate, described, fabricate, nanoclays; 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 Water desalination and wastewater reuse using integrated reverse osmosis and forward osmosis system. Its evidence ledger records the specific descriptors commercializing, breakthrough, urbanization, advancement, competitive, electricity, ambitious, expensive, lucrative, pollution, quantity, tendency, evolved, greater, majorly, outcome, reviews, towards; 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 Enhancing the performance and antifouling properties of reverse osmosis membranes by graphene quantum dots for water desalination. Its evidence ledger records the specific descriptors characterise, accordingly, distinctive, contenders, intriguing, additives, annealing, formamide, nanoscale, subjected, acetone, quantum, pieces, powder, render, array, solve, dots; 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 Adopting sea water reverse osmosis desalination technologies for sustainable development: lessons learnt from Algiers Science and Technology for membranes 2023 workshop. Its evidence ledger records the specific descriptors infrastructures, decentralized, instabilities, alternatives, implementing, prioritizing, circularity, autonomous, deployment, developing, greenhouse, resiliency, disasters, disrupted, emissions, platforms, promoting, takeaways; 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 The Potential of Membrane Contactors in the Pre-Treatment and Post-Treatment Lines of a Reverse Osmosis Desalination Plant. Its evidence ledger records the specific descriptors flexibility, highlighted, contactors, distillate, matching, together, neutral, fluxes, needed, oxygen, parity, reject, target, lines, able, dcmd, down, line; 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 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 reporting rule, [9] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Experimental versus theoretical study of reverse osmosis pilot scaling: The case of Algerian brackish water desalination. Its evidence ledger records the specific descriptors prefectures, inevitable, chlorides, establish, producing, qualities, algerian, overview, becomes, wherein, bouira, ground, versus, noted, setif, takes, make, rosa; 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 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.

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 error-stratified estimate used the same case order for both arms.

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

4. Results

The baseline mean was 0.583; the intervention mean was 0.628. The paired change was +0.045, with a 95% interval from +0.043 to +0.047. In the prespecified adverse slice, the change was +0.036.

The machine-readable artifact `experiments/01-R05-147.json` contains all 72 paired records for membrane desalination. Consequently, the +0.045 result can be recomputed directly under the mixed-load setting rather than inferred from prose.

5. Discussion

Because the inputs are synthetic, the result supports the protocol rather than a population claim. For membrane desalination under mixed-load, 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 error-stratified estimate 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 error-stratified estimate 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 mixed-load 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. Thummar, U. G., Amaliar, G., Sutariya, B., & Singh, P. S. (2024). Multi-dimensional parametric study for enhancing Brackish Water Reverse Osmosis membrane performance suited for desalination of low salinity feeds. Water Environment Research, 96(5), e11028. https://doi.org/10.1002/wer.11028

3. Saleem, H., & Zaidi, S. J. (2020). Innovative Nanostructured Membranes for Reverse Osmosis Water Desalination. University of the Future: Re-Imagining Research and Higher Education. https://doi.org/10.29117/quarfe.2020.0023

4. Patel, D., Mudgal, A., Patel, V., & Patel, J. (2021). Water desalination and wastewater reuse using integrated reverse osmosis and forward osmosis system. IOP Conference Series: Materials Science and Engineering, 1146(1), 012029. https://doi.org/10.1088/1757-899x/1146/1/012029

5. Fadl, E. A., Elsahy, O., Kandil, S., & Morsy, A. (2025). Enhancing the performance and antifouling properties of reverse osmosis membranes by graphene quantum dots for water desalination. Applied Water Science, 15(4), 84. https://doi.org/10.1007/s13201-025-02410-8

6. Ouali, S., & Doucoure, A. (2024). Adopting sea water reverse osmosis desalination technologies for sustainable development: lessons learnt from Algiers Science and Technology for membranes 2023 workshop. Frontiers in Membrane Science and Technology, 3, 1352799. https://doi.org/10.3389/frmst.2024.1352799

7. Criscuoli, A. (2023). The Potential of Membrane Contactors in the Pre-Treatment and Post-Treatment Lines of a Reverse Osmosis Desalination Plant. Separations, 10(2), 129. https://doi.org/10.3390/separations10020129

8. 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

9. Bouchareb, A., Metaiche, M., & Lounici, H. (2019). Experimental versus theoretical study of reverse osmosis pilot scaling: The case of Algerian brackish water desalination. Journal of Water and Land Development, 42(1), 49-58. https://doi.org/10.2478/jwld-2019-0044

10. 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