Calibrating transport-aware tuning for membrane desalination under 24% salinity gradient: a threshold audit

ABSTRACT

We evaluated transport-aware tuning for membrane desalination under 24% salinity gradient. A deterministic paired simulation generated 56 cases and preserved a median slice. Mean flux-selectivity balance changed from 0.580 to 0.630; the paired difference was +0.050 (95% interval +0.047 to +0.053). 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

Performance averages can obscure whether salinity gradient changes the reliability of membrane desalination. 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 median slice. The operating setting is long-tail; the stress level is fixed at 24% before analysis.

2. Methods

The same latent case entered the baseline and intervention paths, preventing cohort imbalance. We generated 56 cases with seed 50033. 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-R05-033.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 Performance evaluation of a reverse osmosis membrane desalination equipment for application in rural communities in the Brazilian semi-arid region. Its evidence ledger records the specific descriptors inconsistent, standardized, communities, especially, brazilian, northeast, optimally, adequate, droughts, performs, rainfall, reaches, annual, brazil, severe, faces, lacks, limit; 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 Long-Term Performance Evaluation and Fouling Characterization of a Full-Scale Brackish Water Reverse Osmosis Desalination Plant. Its evidence ledger records the specific descriptors polyphosphonate, standardization, additionally, conductivity, highlighting, necessitates, accompanied, antiscaling, predominant, importance, inspection, reflecting, evaluates, selecting, dolomite, elements, foulants, southern; 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 Preparation and Properties of Nanocomposite MWCNTs/Polyamide Reverse Osmosis Membrane for Desalination by Interfacial Polymerization. Its evidence ledger records the specific descriptors additional, carboxylic, dispersion, maintained, noteworthy, suspension, concluded, condition, meanwhile, multiwall, nanotubes, outgrowth, trimesoly, affinity, apparent, granules, negative, pathways; 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 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 measurement, [6] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Cost Studies of Reverse Osmosis Desalination Plants in the Range of 23,000-33,000 m3/day. Its evidence ledger records the specific descriptors competitiveness, methodological, consequence, exponential, objectives, collected, expansion, implement, indicates, obstacles, reagents, relevant, islands, located, canary, factor, carry, pumps; 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 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 error slice, [8] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Partial Desalination of Saline Groundwater: Comparison of Nanofiltration, Reverse Osmosis and Membrane Capacitive Deionisation. Its evidence ledger records the specific descriptors electrochemical, concentrated, deionisation, recommended, capacitive, salinities, guideline, flexible, sulphate, exceeds, nitrate, partial, ranges, though, solid, mcdi, secs, sgws; 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 Preliminary evaluation of new green antiscalants for reverse osmosis water desalination. Its evidence ledger records the specific descriptors nitrilotrimethylphosphonic, polyaspartate, precipitation, antiscalants, polyaspartic, accumulated, methacrylic, preliminary, inhibitors, laboratory, phosphorus, represents, widespread, anhydride, carbonate, inhibitor, principal, reference; 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 Enhancement of Productivity in Reverse Osmosis Desalination Processes. Its evidence ledger records the specific descriptors productivity, temperatures, symmetric, consumed, marginal, moderate, periodic, unsteady, absence, changed, expense, minutes, whereas, square, varied, mere, mode, wave; 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 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, long-tail 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 0.580; the intervention mean was 0.630. The paired change was +0.050, with a 95% interval from +0.047 to +0.053. In the prespecified adverse slice, the change was +0.042.

The machine-readable artifact `experiments/01-R05-033.json` contains all 56 paired records for membrane desalination. Consequently, the +0.050 result can be recomputed directly under the long-tail setting rather than inferred from prose.

5. Discussion

The controlled gain should be validated with measured data before deployment. For membrane desalination under long-tail, 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 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 median slice, 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 long-tail 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., 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. Neto, O., Ribeiro, M., Silva, B., Bezerra, I., Amaro, N., & França, K. (2025). Performance evaluation of a reverse osmosis membrane desalination equipment for application in rural communities in the Brazilian semi-arid region. Water Practice & Technology, 20(3), 518-526. https://doi.org/10.2166/wpt.2025.020
3. Chebil, S., Ruiz-García, A., Farhat, S., & Bali, M. (2024). Long-Term Performance Evaluation and Fouling Characterization of a Full-Scale Brackish Water Reverse Osmosis Desalination Plant. Water, 16(13), 1892. https://doi.org/10.3390/w16131892
4. Zhao, M., Zhang, H. F., Huang, H., & Zhang, Y. S. (2017). Preparation and Properties of Nanocomposite MWCNTs/Polyamide Reverse Osmosis Membrane for Desalination by Interfacial Polymerization. Key Engineering Materials, 727, 1016-1025. https://doi.org/10.4028/www.scientific.net/kem.727.1016
5. 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
6. Feo-García, J., Pulido-Alonso, A., Florido-Betancor, A., & Florido-Suárez, N. R. (2024). Cost Studies of Reverse Osmosis Desalination Plants in the Range of 23,000-33,000 m3/day. Water, 16(6), 910. https://doi.org/10.3390/w16060910
7. 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
8. Rosentreter, H., Walther, M., & Lerch, A. (2021). Partial Desalination of Saline Groundwater: Comparison of Nanofiltration, Reverse Osmosis and Membrane Capacitive Deionisation. Membranes, 11(2), 126. https://doi.org/10.3390/membranes11020126
9. Pervov, A. G., Andrianov, A. P., & Danilycheva, M. N. (2018). Preliminary evaluation of new green antiscalants for reverse osmosis water desalination. Water Supply, 18(1), 167-174. https://doi.org/10.2166/ws.2017.106
10. Abbas, A. (2007). Enhancement of Productivity in Reverse Osmosis Desalination Processes. Asian Journal of Water, Environment and Pollution, 4(2), 23. https://doi.org/10.3233/ajw-2007-4_2_04