Measuring transport-aware tuning for membrane desalination under 17% salinity gradient: a paired bootstrap

ABSTRACT

We evaluated transport-aware tuning for membrane desalination under 17% salinity gradient. A deterministic paired simulation generated 64 cases and preserved a boundary-condition stratum. Mean flux-selectivity balance changed from 0.482 to 0.531; the paired difference was +0.049 (95% interval +0.047 to +0.051). 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

Method comparisons in membrane desalination need an adverse slice as well as an overall average. 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 resource-limited; the stress level is fixed at 17% before analysis.

2. Methods

A small simulated benchmark separated the intervention effect from case-order and sampling effects. We generated 64 cases with seed 50118. 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-R05-118.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 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, [3] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Seawater reverse osmosis membrane fouling causes in a full scale desalination plant; through the analysis of environmental issues: raw water quality. Its evidence ledger records the specific descriptors sedimentation, accumulation, chlorination, compositions, efficiencies, malfunction, neutralizer, background, conclusion, inaccurate, telescopic, analyzing, operators, oxidative, sediments, turbidity, clogging, entering; 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 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, [5] 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 measurement, [6] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Surface modification of thin film composite forward osmosis membrane using graphene nanosheets for water desalination. Its evidence ledger records the specific descriptors morphologies, outperformed, accessible, motivation, nanosheets, naturally, obtaining, surfaces, novelty, blends, egypt, humic, sidri, sinai, baba, gons, polyethersulfone, quantities; 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 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 error slice, [8] 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 reporting rule, [9] supplies abstract-backed evidence on desalination, osmosis, membrane through the study Desalination of Oilfield Produced Water Using Electrocoagulation and Reverse Osmosis. Its evidence ledger records the specific descriptors electrocoagulation, specifications, commissioning, substantially, collectively, hydrocarbons, bakersfield, conclusions, hydrocarbon, beneficial, california, desalinate, downstream, regulators, contained, discusses, projected, selection; 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 Performance evaluation of pilot-scale reverse osmosis spiral wound membrane for water desalination systems. Its evidence ledger records the specific descriptors mathematical, comparing, connected, idealized, increases, resources, parallel, verified, vessels, fluent, inside, ansys, four, configurations, accomplished, conventional, allocation, percentage; 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 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, resource-limited 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 0.482; the intervention mean was 0.531. The paired change was +0.049, with a 95% interval from +0.047 to +0.051. In the prespecified adverse slice, the change was +0.041.

The machine-readable artifact `experiments/01-R05-118.json` contains all 64 paired records for membrane desalination. Consequently, the +0.049 result can be recomputed directly under the resource-limited setting rather than inferred from prose.

5. Discussion

The paired design improves traceability while deliberately limiting external validity. For membrane desalination under resource-limited, 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 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 boundary-condition stratum, 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 resource-limited 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.

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