Stress-testing transport-aware tuning for membrane desalination under 44% salinity gradient: a hold-out check

ABSTRACT

We evaluated transport-aware tuning for membrane desalination under 44% salinity gradient. A deterministic paired simulation generated 64 cases and preserved a rare-condition slice. Mean flux-selectivity balance changed from 0.516 to 0.562; the paired difference was +0.046 (95% interval +0.044 to +0.049). 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

This study isolates one operational question in membrane desalination: whether a transparent control survives noisy-input inputs. The experiment focuses on Desalination Driven by Temperature Gradient Coupled with Surface Wettability in a Graphene Channel. 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 rare-condition slice. The operating setting is noisy-input; the stress level is fixed at 44% before analysis.

2. Methods

A fixed generator created matched inputs; only the prespecified intervention differed between arms. We generated 64 cases with seed 50042. 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-R05-042.json`.

Reference [1] is used in Methods, not only as background: its work on Desalination Driven by Temperature Gradient Coupled with Surface Wettability in a Graphene Channel 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 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 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 A New Method for a Polyethersulfone-Based Dopamine-Graphene (xGnP-DA/PES) Nanocomposite Membrane in Low/Ultra-Low Pressure Reverse Osmosis (L/ULPRO) Desalination. Its evidence ledger records the specific descriptors photoelectron, recoveries, stabilized, quenching, utilizing, porosity, recorded, altered, species, cycles, stable, uptake, ulpro, room, xgnp, polyethersulfone, characterized, preparation; 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 Experimental Evaluation of the Performance of a Flat Sheet Reverse Osmosis Membrane Under Variable and Intermittent Operation Emulating a Photovoltaic-Driven Desalination System. Its evidence ledger records the specific descriptors microcontroller, experimentally, fluctuations, intermittent, particularly, representing, fluctuating, instability, compaction, emulating, frequency, highlight, longevity, regulated, replicate, scenarios, adjusted, scenario; 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 Economic Feasibility of Solar-Powered Reverse Osmosis Water Desalination: A Comparative Systemic Review. Its evidence ledger records the specific descriptors systematically, comparatively, disparities, multistage, reservoirs, attention, locations, rainwater, depleted, domestic, drainage, received, recently, supplies, systemic, article, drought, extreme; 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 Water permeability of nanoporous graphene at realistic pressures for reverse osmosis desalination. Its evidence ledger records the specific descriptors equivalently, environment, tremendous, maintains, permeable, realistic, thickness, inherent, maintain, nanopore, question, assumed, drawing, precise, answer, does, calculated, nanoporous; 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 Graphene foam membranes with tunable pore size for next-generation reverse osmosis water desalination. Its evidence ledger records the specific descriptors controlling, hindered, tunable, foam, next, generation, challenges, pore, development, achieving, density, carbon, size, graphene, membranes, water, reverse, desalination; 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 rare-condition slice. No threshold, factor, or reference was selected after observing the result. The hold-out check used the same case order for both arms.

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

4. Results

The baseline mean was 0.516; the intervention mean was 0.562. The paired change was +0.046, with a 95% interval from +0.044 to +0.049. In the prespecified adverse slice, the change was +0.035.

The machine-readable artifact `experiments/01-R05-042.json` contains all 64 paired records for membrane desalination. Consequently, the +0.046 result can be recomputed directly under the noisy-input setting rather than inferred from prose.

5. Discussion

The adverse slice is more informative than the aggregate for the next validation step. For membrane desalination under noisy-input, the sign of the flux-selectivity balance change remained positive in both the full set and the rare-condition slice. This supports a focused follow-up on salinity gradient using measured inputs and the same hold-out check 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 rare-condition slice, and the hold-out check 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 noisy-input generator. A real-data study should retain salinity gradient and the rare-condition 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.

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