Web-based Framework for Multi-Objective Optimization of Managed Aquifer Recharge

Full Abstract:

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Motive

Optimizing MAR systems is crucial for balancing of performance and efficiency.

Multi-objective optimization helps both engineers and policymakers to over-come trial-and-error approaches, leading to more sustainable MAR designs.

Goal

Introducing the first design steps and the general structure of a framework that integrates the capabilities of the existing web-based groundwater modelling platform **INOWAS (www.inowas.com)** with a hybrid evolutionary algorithm for optimizing MAR design. This is achieved by balancing trade-offs between competing and conflicting objectives (Groundwater quality, recovery efficiency, economic feasibility, …etc.)

Methods

Combining groundwater flow and transport models from **MODFLOW** family with:

- Global search capabilities (using **Genetic** algorithm) and,
- Local refining methods (using **Simplex** algorithm).

This combination allows exploring complex solution spaces.

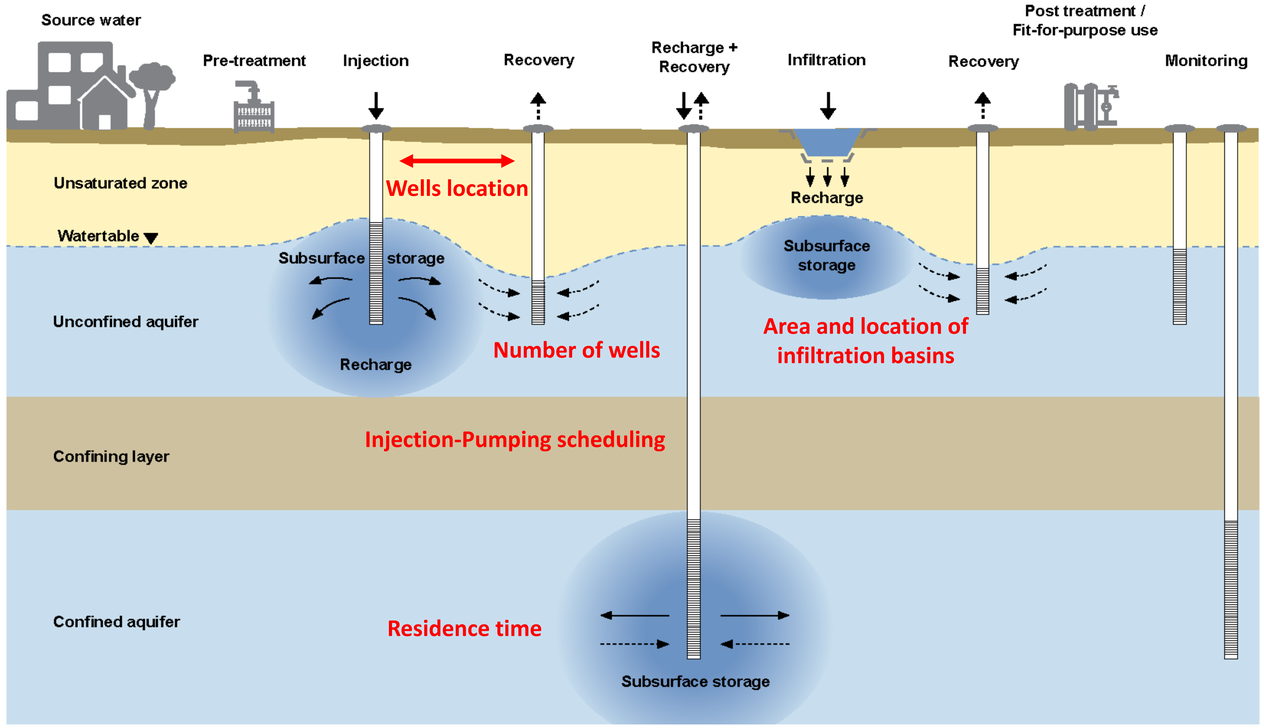

Fig 1: General scheme of Multi-Objective Optimization of Managed Aquifer Recharge. Texts in red explain the most common key variables which are optimized to balance the conflicted MAR objectives (MAR | Western Australian Government, 2021).

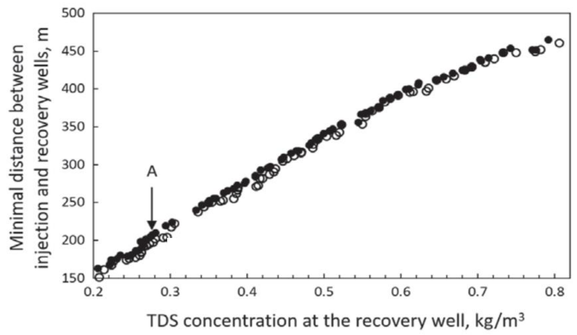

Fig 2: Pareto optimal solutions for minimizing TDS and maximizing wells spacing .

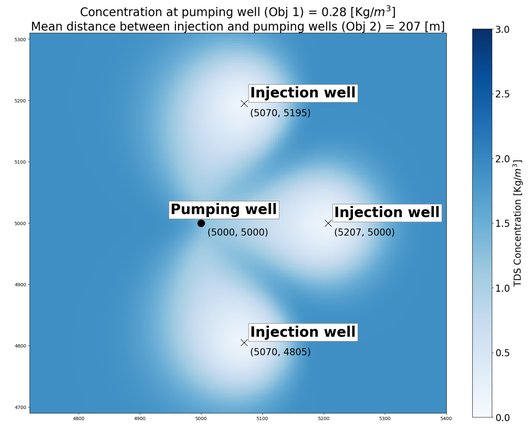

Fig 3: Optimal location of injection wells by maximizing average distance to pumping well while minimizing TDS concentration.

Case study

Synthetic scenario was conducted by Fatkhutdinov & Stefan et al. (2019) and reproduced as shown in Fig. 2 and 3, where treated wastewater is injected into a saline aquifer.

Results

Solutions are expressed as pareto fronts (Fig. 2), which represent a set of optimal non-dominated trade-off solutions, where no objective can be improved without compromising another.

- **Objective 1:** Maximize average Injection-Pumping well distance
- **Objective 2:** Minimize TDS at Pumping well
- **Constraints:** TDS < 0.3 Kg/m³, Wells spacing > 150 m
- **Key Variable:** Wells spacing (Coordinates)

✓ **Pumping-Injection average distance:** ≈ 207 m

✓ **Simulated TDS at Pumping well:** 0.28 Kg/m³

References

Fatkhutdinov, A., & Stefan, C. (2019). Multi-Objective Optimization of Managed Aquifer Recharge. Groundwater, 57(2), 238–244. https://doi.org/10.1111/gwat.12793

Managed aquifer recharge | Western Australian Government. (2021, January 22). https://www.wa.gov.au/service/environment/business-and-community-assistance/managed-aquifer-recharge

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