Combining aquifer storage and recovery with reverse osmosis (ASRO Westland)

An innovative solution for a sustainable freshwater supply

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Introduction

Coastal areas are marked by high freshwater demands, but yet a low freshwater availibility. Use of the local eco-systems via aquifer storage and recovery (ASR) of temporary freshwater surpluses and reverse osmosis (RO) of brackish-saline groundwater are potential solutions for freshwater supply in coastal areas. Both techniques have their drawbacks, however, since ASR in coastal aquifers is marked by freshwater losses by buoyancy effects in the saline groundwater (water shortage remains), while RO is accompanied by a saline waste stream (unsustainable). In DESSIN we demonstrate that a sustainable and reliable freshwater supply can be achieve by combining both techniques in one system (ASRO).

Context

The Westland area in The Netherlands is the Dutch largest intensive greenhouse horticultural area, justicing its second name 'the glass city'. A mismatch in precipitation and water demand results in a large winter freshwater surplus here, which is discharged to sea as only a small part can be stored in basins or tanks. Fresh irrigation water supply is realized primarily by storing low EC rainwater from greenhouse roofs in basins, complemented by brackish water desalination (RO).

Site description: ASRO Westland

At the Westland field site, the freshwater surplus of 270,000 m^2 of greenhouse roof is collected, filtrated, and injected deep into the target aquifer (23-37 m below sea-level; 4000 – 5000 mg Cl/l) via dedicated, recently developed multiple partially penetrating wells. Upon storage, the water is recovered during spring/summer. Unmixed freshwater is recovered at the aquifer top for direct use. During later recovery, the deep well of the system is used as a 'Freshkeeper' for interception of of brackish-saline groundwater. This water is directly re-injected in a deeper aquifer (2014) or desalinated via RO for use as irrigation water (2015-2018).

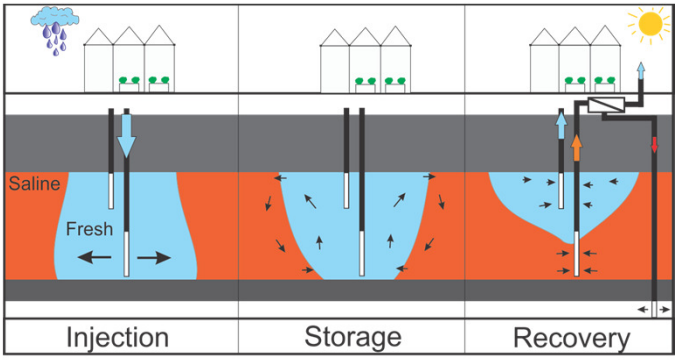

Figure 1: Storage and recovery of freshwater via ASRO

Methodology

The aim of this study is to optimize and demonstrate freshwater supply from brackish aquifers with a combined ASRO system. Specific objectives and corresponding methods are listed in Table 1.

Specific aims	Method
To demonstrate the added value of an ASRO system on freshwater recovery.	Field study, groundwater modelling
Assessment of membrane clogging by varying redox conditions of the RO feedwater	Field study, groundwater modelling
To demonstrate the impact of freshwater supply from brackish aquifers on regional groundwater quality and Water Framework Directive goals.	Regional groundwater modelling
To demonstrate the effect of enhanced subsurface iron removal on membrane clogging.	Field study

Table 1: Specific aims and method for the DESSIN Westland ASRO demonstration

Figure 2: The Westland ASRO well field

Results & Discussion

ASR freshwater recovery at Westland, without RO

In Figure 3, it is shown that the modelled long-term recovery efficiencies for direct use at the Westland demonstration site increases from approximately 30% for a simple, conventional ASR well to >60% when the Freshkeeper (incl. RO) is applied. This increase in freshwater availability underlines the importance of the dedicated design proposed.

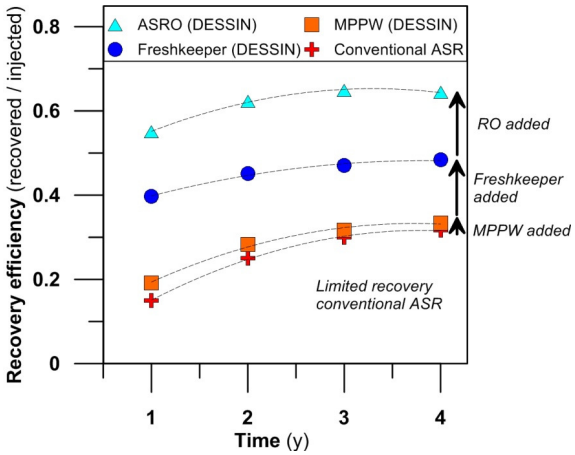

Figure 3: Modelled ASR recovery efficiencies

Additional freshwater production via RO

The Freshkeeper is functioning since 2014. The RO-installation uses brackish water membranes to remove 99.5% of the salts in the water abstracted by the Freshkeeper. Mobilisation of colloids in the target aquifer during rainwater injection are considered the main threat for the RO-application. In the Summer of 2015, however, the plant has been operating on a recovery of 50% without any indication of clogging.

Conclusions

The Westland ASRO demonstration shows the potential of dedicated ASR concepts in coastal aquifers to manage freshwater resources and enable a sustainable freshwater supply. Focus is now on enhanced production via RO and evaluation of the effects on the local and regional groundwater system.

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