Subsurface water solutions
An overview

Session 14

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Why subsurface water solutions?

**Subsurface**

- Suffers from salinization, depletion
- Ideal medium for (storage of) freshwater (surpluses)
  - Large capacity, limited spatial footprint
  - Quality conservation
  - Desinfection
- But, abstraction and storage and recovery of freshwater in coastal impact has been rather unsuccessful

SUBSOL has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 642228
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Overexploitation of freshwater lenses

Inefficiency of conventional ASR

Upconing of saline water

Enlarge natural freshwater lenses

Enable ASR in brackish aquifers

Prevent saltwater upconing into wells
Subsurface Water Solutions (SWS)

- Couple natural ecosystem (service) with technology
- Enhanced protection and utilization of coastal freshwater resources
- Flexible and adaptive to the local setting
- Build on novel well designs and configurations, and sophisticated ICT
- Tested in field scale pilots (Technology Readiness Level 7-8).

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**Freshmaker**

Infiltration through **horizontal wells**, to enlarge and utilize freshwater lenses in coastal areas.

**Objective of SWS:**
- Temporal storage
- Freshwater lenses
- Yes
- Artificial recharge: Yes
- Saltwater interception: No
- Well type: HDDW
- Water treatment: Pre-treatment

Zuurbier et al. (2016)
**Multiple Partially Penetrating Wells (MPPW)**  
(deep injection, shallow recovery in superficial brackish aquifers)

**Objective of SWS:** Temporal storage  
**Target conditions:** Brackish aquifers  
**Artificial recharge:** Yes  
**Saltwater interception:** Optionally  
**Well type:** MPPW  
**Water treatment:** Pre-treatment

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Zuurbier et al. (2016)
Freshkeeper

Interception of upconing brackish groundwater

Objective of SWS: Protection of well fields
Target conditions: Groundwater quality (stratified)
Artificial recharge: No
Saltwater interception: Yes
Well type: PP, MPPW
Water treatment: Optional desal

Zuurbier et al. (2016)
Subsol (EU H2020): launch SWS

Only interesting when it really works and is taken up by end users…
Example 1: SWS for irrigation water supply

ASR-Coastal

Freshmaker
Concept: aquifer storage and recovery

- ASR: aquifer storage and recovery (using wells)
- Bridge between moments of availability and demand
- Buoyancy makes ASR unviable in coastal areas!
Need for freshwater storage agriculture

- Mismatch freshwater availability and demand
  - Coastal areas: freshwater shortage and salinization

- Traditionally
  - Aboveground storage of freshwater surpluses: spatial claim, poor water quality conservation
  - Unsustainable solutions (desalination + brine disposal)

- Aquifer storage and recovery (ASR) would be more elegant...

*Horticulture Greenport Eastland – Westland (NL): rainwater availability and demand*
Storage versus brackish water desal

- Mismatch freshwater availability and demand
  - Coastal areas: freshwater shortage and salinization

- Traditionally
  - aboveground storage of freshwater surpluses: spatial claim, poor water quality conservation
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- Aquifer storage and recovery (ASR) would be more elegant…
Set-up ASR for greenhouses

Rain: Na: 1-10 mg/l
Drinking water: Na: 50 mg/l
Groundwater: Na: 50 - 3000 mg/l
Surface water: Na: 50 - 500 mg/l

Required: Na < 11 mg/l

Slow sand filtration
The Netherlands, ’80s: small-scale, horticulture ASR (old)

- Rapid increase of salinity during recovery
- Caused by buoyancy
- Success limited to zones with fresh groundwater
SWS (new): ASR-Coastal

- Adapt to coastal conditions
  - Multiple partially penetrating well
SWS (new): Freshmaker

- Adapt to coastal conditions
  - Horizontal directionally drilled wells

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Field realisations

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Research
Operation with end users

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ASR-Coastal

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Combination with desalination

ASR + ‘Freshkeeper’ + RO: ASRRO

- Robust supply of high quality water
- Infiltration and production of freshwater in balance
  - Mitigates production of saline waste stream

Westland ASRRO
Combination with desalination

ASR + ‘Freshkeeper’ + RO: ASRRO

- Robust supply of high quality water
- Infiltration and production of freshwater in balance
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Infiltration:

Recovery
Role of ICT

*SWS benefit from ICT…*

- No attention from end user required
- Prevents mistakes
- Enlarges efficiency
- Enable anticipation on weather / water demand forecasts
Full-scale replication

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Full-scale replication

Nieuw-Prinsenland, Dinteloord

- 200 ha horticulture (mainly tomatoes)
- 50 ha industry
- 120 ha sugar factory
- Rainwater in small basins = primary source
- Estimated 15% deficit (200,000 m³/yr)
Treated effluent sugar factory = source

- 2,5 mln ton of sugar beets
- 1,8 mln m³ of waste water produced
- 280,000 m³ is treated
- 200,000 m³ treated water produced
- 60 m³/h from September to January
- ASR-Coastal to store the water until demand

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Modelling of the ASR wells

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Predicted use of the ASR water

- Based on historic rainfall data
New directions: ASR-Coastal to create Urban Waterbuffer

- Reduce rainwater run-off
- Treat by small urban wetlands
- Store and recover with ASR-Coastal
- Use recovered water for urban use
  - Irrigation
  - Ponds
  - Cleaning
Example 2: Freshkeeper to safeguard drinking water abstraction
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Saltwater

Freshwater

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- Reference sites (since 2012) show robustness
- Market uptake: replications well underway in NL
- International breakthrough?