Web-Based Modelling Framework for Planning and Assessment of Managed Aquifer Recharge Applications

Dr. Catalin Stefan

Dresden Nexus Conference (DNC2017) | 17-19 May 2017
Managed aquifer recharge

Natural groundwater recharge

Unintentional aquifer recharge

What is managed aquifer recharge?

Managed Aquifer Recharge As a Tool for Adaptation of Cities to Global Change

Dr. Catalin Stefan

Source: http://ponce.sdsu.edu/groundwater_sustainable_yield_01.jpg
MAR for global change mitigation

Water risk index

https://marportal.un-igrac.org
Objective

Development of a decision support system (DSS) for groundwater management applications using modern web-based technologies, supported by GIS functionality and process-based simulations

Advantages of INOWAS-DSS

- Web-based (web browser)
- Open source
- Tools of varying complexity (empirical, analytical, numerical)
- Cloud modeling (parallel / scalable)
- Online documentation
- Accessibility of data and projects worldwide
- Easy collaboration between various modelers/decision makers

Funded by Federal Ministry of Education and Research
INOWAS DSS Toolbox

**Simple** tools derived from data mining and empirical correlations

**Practical** implementation of analytical equations of groundwater flow

**Reliable** simulations using complex numerical flow models (i.e. MODFLOW)

The applications are based on a collection of simple, practical and reliable web-based tools of various degrees of complexity. The tools are either included in application-specific workflows or used as standalone modelling instruments.

**EXAMPLES OF TOOLS**

T07: APPLICATION-SPECIFIC SCENARIOS ANALYZER

This tool makes use of the output files of the MODFLOW-based model and uses them for the customized analysis of user-defined model scenarios.
INOWAS DSS Toolbox

T01. ASR efficiency assessment (Ward)
T02. Groundwater mounding calculator (Hantush)
T03. Numerical model setup (MODFLOW, MT3DMS, SEAWAT)
T04. GIS-based site suitability mapping (Rahman)
T05. Optimisation of ASR well location
T06. MAR method selection tool
T07. Application-specific scenarios analyser
T08. 1D Analytical transport model (Ogata-Banks)
T09. Simple saltwater intrusion equations (T09_a, b, c, d, e)
T10. Clogging estimation
T11. Bank filtration simulator
T12. Maximal hydraulic loading rate
T13. Travel time through unconfined aquifer (T13_a, b, c, d, e)
T14. Pumping-induced river drawdown (T14_a, b, c, d)
T15. Stochastic weather generator
T16. Saturated soil hydraulic conductivity (T16_a, b, c, d)
T17. ASR recovery efficiency
T18. SAT basin design
T19. Planning of MAR schemes
T20. Maximum allowable well injection pressure
T21. Estimation of aquifer storage capacity
INOWAS DSS App Configurator

- **SIMPLE APPROACH**

  In this workflow, the tools are not interlinked and can be used independently from each other:

  - **T09** Simple saltwater intrusion equations
    - The tool contains analytical equations that can be used to analyse or predict the location of the interface between sea water and fresh water in a groundwater system (read more).

  - **T01** ASR efficiency index
    - Assessment of the suitability of a proposed site for an ASR system based on lateral groundwater flow, dispersive mixing, mixed convection and free convection of an aquifer (read more).

- **COMPLEX APPROACH**

  The tools in this workflow are interlinked. The tools T03 and T07 must be selected, we also recommend T01 and T04, the others are optional.

  - **T06** MAR method selection tool
    - The data-driven tool provides support in the selection of suitable MAR methods based on the analysis of several hundreds of MAR case studies worldwide (read more).

  - **T04** GIS-based site suitability mapping
    - This webGIS-based multi-criteria decision analysis tool is used for the preliminary ranking of areas that could be suitable for MAR application (read more).

  - **T01** ASR efficiency index
    - Assessment of the suitability of a proposed site for an ASR system based on lateral groundwater flow, dispersive mixing, mixed convection and free convection of an aquifer (read more).

  - **T03** Numerical model setup (SEAWAT)
    - The tool helps to setup a new SEAWAT model for a study area e.g. to better understand the local groundwater flow system or as a basis for scenario analysis (read more).

  - **T07** Application-specific scenario analyzer
    - This tool makes use of the output files of the SEAWAT-based model and uses them for the customised analysis of user-defined model scenarios (read more).
INOWAS DSS Dashboard

**Dashboard**

- **DATASETS (38)**
- **PROJECTS (4)**
- **APPLICATIONS (5)**
  - A03. Restoration of groundwater levels
  - A05. Assessment of saltwater intrusion
  - A06. Design optimisation of MAR schemes
  - A10. Assessment of clogging development
  - A14. Parameter estimation

**Tools (8)**

- T06. MAR method selection
- T04. GIS-based site suitability mapping
- T01. ASR efficiency index
- T03. Numerical model set-up (MODFLOW)
- T15. Stochastic weather generator
- **T09. Simple saltwater intrusion equations**
- T13. Travel time through unconfined aquifer
- T19. Planning of MAR schemes
- T20. Maximum well injection pressure

**Details**

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INOWAS DSS Toolbox

T09. Saltwater intrusion equations

T09_c. Saltwater intrusion // Upconing

BACKGROUND

Calculation

OK

The calculated upconing level of 8.5 m is lower than the critical elevation of 9.0 m so saltwater shouldn't enter the well. However, we recommend a maximum pumping rate of 2100.6 m³/d.

Pumping rate, Q (m³/d)

Hydraulic conductivity, K (m/d)

Pre-pumping distance, dm)

Density of freshwater (g/cm³)

Density of saltwater (g/cm³)
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T07. Scenarios analyzer
T07. Scenarios analyzer
INOWAS DSS Toolbox

T07. Scenarios analyzer

**SCENARIOS**

- **BASE SCENARIO HANOI 2005-2007**

- **SCENARIO 1**
  - Simulation of MAR type river bank filtration

- **SCENARIO 2**
  - Simulation of MAR type injection wells

- **SCENARIO 3**
  - Combination of MAR types river bank filtration and injection wells.

**Layer 3 head**

**Active Points**

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**Graph**

- 02/01/2006
- **Point 0 Base Scenario Hanoi 2005-2007**
  - -0.7250723242759705
- **Point 1 Base Scenario Hanoi 2005-2007**
  - -5.515626430581475
- **Point 2 Base Scenario Hanoi 2005-2007**
  - -6.7395234180797119
INOWAS DSS

- allows the **integrated use of various model complexities**
- provides **best accessibility of project data** and **multi-institutional collaboration** through web-based implementation
- makes use of a combination of **widely available open-source tools**
- promotes the **case-based reasoning approach** as additional support for parameter estimation and solution finding

Public release expected for end of 2017

https://tu-dresden.de/uw/inowas
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