Delineating ‘groundwater bodies’ and optimisation of the groundwater monitoring network (in the scope of the EC Water Directive 2000/60/CE)

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Outline
- delineating ‘groundwater bodies’
  theory ... and practice
- optimisation of the groundwater monitoring network
  theory ... and practice
- test application of the SEQ-ESO as groundwater quality evaluation tool
  ...in the scope of the EC Water Directive 2000/60/CE)

Delineating ‘groundwater bodies’: theory

Elements of Characterization

Hydrology
- annual precipitation

Geology
- stratigraphy
- thickness
- overlying strata

Hydrogeology
- recharge (precipitation, surface waters, groundwaters, springs, irrigation)
- hydraulic conductivity
- annual piezometric amplitudes

Pressures
- land use
- water abstractions
- artificial recharge
- main infrastructures
- associated aquatic ecosystems

Delineating ‘groundwater bodies’: aims: characterization & management

- initial characterisation requires collation of data on pressures on GW body(ies):
  - diffuse sources of pollution
  - point sources of pollution
  - abstraction
  - artificial recharge
  - general character of overlying strata in recharge areas and dependent ecosystems
- use only existing data at initial characterisation
- data on distribution of pressures, observed impacts
**Delineating ‘groundwater bodies’: practice**

Management reasons:
- Quantity
- Quality

http://environnement.wallonie.be/de/eso/atlas/#1.1res
(Observatoire des Eaux Souterraines, DGRNE, Ministère de la Région Wallonne, 2002)

**Optimisation of groundwater monitoring network**

- Collecting all existing data (quantity and quality)
- Analysis of geological/hydrogeological conditions
- On the basis of few criteria: choice of the points for the monitoring network

*Special ‘vulnerable’ zones*
Optimisation of groundwater monitoring network

Collecting all existing data (quantity and quality)

Optimisation of groundwater monitoring network

8 km

Optimisation of groundwater monitoring network

Analysis of geological/hydrogeological conditions

...on the basis of few criteria: choice of the points for the monitoring network

- upward or downward position of the measurement point (with respect to the piezometry)
- integrating/representative character of the measurement/sampling point
- variability of the historical measured data
- point contamination sources
- accessibility of the measurement/sampling point
- well equipment
- present state and ownership of the well
- depth
- ...

1 point/25 km² in special zones and 1 point/100 km² in other zones
### Optimisation of groundwater monitoring network

- Collecting all existing data (quantity and quality)
- Analysis of geological/hydrogeological conditions
- On the basis of few criteria: choice of the points for the monitoring network

#### Criteria:

- **Special 'vulnerable' zones**

#### Network Density:

- 1 point/25km² in special zones and 1 point/100 km² in other zones

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#### GW Levels: Quantity Control

#### GW Concentrations: Quality Control
Optimisation of groundwater monitoring network

- 1 point/25km² in special zones and 1 point/100 km² in other zones
- 10 points
- 2 galleries
- 1 source
- 7 wells

Test of the SEQ-ESO as a groundwater quality evaluation tool

Objectives
- check the groundwater quality with respect to the existing standards (nitrates, pesticides, ...)
- check the drinking water standards without heavy processing at the source (resource)
- check the quality objectives for the depending surface ecosystems
- check anomalies with respect to the 'natural state' and to the present background
- then select the most difficult objective for synthesis, conclusions and remediation

'Système d’Evaluation de la Qualité des Eaux Souterraines' (SEQ-ESO) developed by the French 'Agences de l’Eau'
- coherent with SEQ for surface water quality
- evaluation in function of the use
- distinction between different kinds of water quality 'alterations'

Test of the SEQ-ESO as a groundwater quality evaluation tool: example of result

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Test of the SEQ-ESO as a groundwater quality evaluation tool

- 17 different possible alterations ... receiving a score between 0 and 100
- 3 main functions of groundwater: consumed water (different kind of use), patrimonial state, chemical aptitude for biology of surface waters

Adaptations:
- only three kinds of index: 1) drinking water;
  2) patrimonial state;
  3) global
- six groups of alteration
- modification of some thresholds (gw quality limits between two categories)

Usage AEP (alimentation en eau potable):
- Etat patrimonial:
  1) Eau de qualité optimale pour être consommée NO₃ = 25 mg/l I = 80%
  2) Eau de très bonne qualité NO₃ = 10 mg/l
  3) Eau dont la composition est naturelle ou "sub-naturelle".
    NO₃ = 20 mg/l I = 60%
  4) Eau de bonne qualité NO₃ = 20 mg/l
  5) Eau de composition proche de l’état naturel, mais détection d’une contamination d’origine anthropique.
    NO₃ = 50 mg/l I = 40%
  6) Eau de qualité moyenne NO₃ = 50 mg/l
  7) Eau non potable nécessitant un traitement de potabilisation NO₃ = 100 mg/l I = 20%
  8) Eau de qualité médiocre NO₃ = 100 mg/l
  9) Eau de mauvaise qualité

Conclusions: ... a lot of work!!
the choices and the work done now will have an enormous influence on the future management of the groundwater bodies!
Large-scale groundwater modelling within the PIRENE programme in the Walloon Region of Belgium

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Quantitative and qualitative objectives

- Collect of data and using existing characterization of aquifers
- Hydrogeological balance of the aquifers
- Effect of the infiltration fluxes
- Estimation of groundwater-river interactions
- Impacts of pumping, recharge, ... and any changes in stress-factors
- Trends of the groundwater quantity for different scenarios of the future

Modelling groundwater quantity

- Trends in nitrates and pesticides
- Effect of the infiltration fluxes
- Estimation of groundwater-river interactions
- Impacts of any change in stress-factors

Modelling groundwater flow and transport at an unusual scale: the scale of the Walloon Region

5 different steps:

- Collect of data
- Data Base and formatting data
- Development of numerical tools and tests
- Conceptual model for each zone
- Implementation of the chosen model, calibration, validation and use for scenarios

Methodology of work

Adaptation of the SUFT3D code

Modelling groundwater flow and transport at an unusual scale: the scale of the Walloon Region

simplified approaches
development of new boundary conditions
improvement of computation performances

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Reservoir Saturation</th>
<th>Modelling of mixing</th>
<th>Advection-Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir Saturation Simple</td>
<td>OK</td>
<td>Impossible</td>
<td>Impossible</td>
</tr>
<tr>
<td>Reservoir Saturation Dual</td>
<td>OK</td>
<td>OK</td>
<td>Impossible</td>
</tr>
<tr>
<td>Ecoulement en milieu poreux</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>
Tests of a regional discretization

Mean surface of an element = 0.4 km²
difficult to take into account explicitly rivers, wells, ...