COST Action 629
Integrated methods for assessing water quality, 21-22/10/2004
Louvain-la-Neuve, Belgium

Aggregated indicators from an optimized groundwater monitoring network :

examples in Walloon region of Belgium for implementation of the European Water Directive

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The groundwater quality assessment system SEQESO

- *system developed initially by French Water agencies*
- *based on chosen thresholds values defining quality classes*
- *thresholds values can vary relatively to the kind of 'water use':*
  - ** water production for drinking water, industry, agricultural uses (animal watering and irrigation), energy (heat pumps),etc.*
    - ➡ *"Drinking water supply" (ADE for 'Aptitude à la Distribution de l'Eau') is recognized as the main use introduced in the SEQESO*
  - ** patrimonial status (i.e. quality deviation from the natural status)*
  - ** ability to sustain biology in the associated water courses (BIO)*

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The groundwater quality assessment system SEQESO

- *Drinking water supply (ADE):*
  - *ADE-S1 (blue/green) ex: nitrates 25 mg/l*
  - *ADE-S3 (green/orange) ex: nitrates 50 mg/l*
  - *ADE-S4 (orange/red) ex: nitrates 100 mg/l*
- *Patrimonial status (PAW for 'état PAtrimonial en Wallonie')*
  - *PAW-S1 (blue/green) ex: nitrates 10 mg/l)*
  - *PAW-S2 (green/yellow) ex: nitrates 25 mg/l*
  - *PAW-S3 (yellow /orange) ex: nitrates 37.5 mg/l*
  - *PAW-S4 (orange/red) ex: nitrates 50 mg/l*
- *Ability to sustain biology in the associated water courses (BIO)*

  5 quality classes are defined.

  the 4 thresholds are exactly the same as for surface water (assuming 100% of feeding from groundwater !)

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The groundwater quality assessment system SEQESO

- *each value corresponding to a particular concentration for a parameter is converted into an non-dimensional index*
- *parameters are then regrouped into consistent packages called "alterations"*
  - *mineralisation (pH, hardness, Cl^-, SO_4^{--}, …)*
  - *nutrients and organic matter (N, P, TOC, …)*
  - *solids and filterable matters (NTU, Fe, Mn, Al, …)*
  - *mineral pollutants (Cu, Zn, As, B, CN^-,Cd, …)*
  - *pesticides (atracine, bromacil, diuron, …)*
  - *other organic pollutants (TCE, HCB index, …)*

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The groundwater quality assessment system SEQESO

Advantage:

combining the 'drinking water use' (ADE) and the 'patrimonial status' (PAW) → to obtain a general expression of the groundwater quality

(GQW = General Quality in Wallonia)

Ex: nitrates

Drinking water use:		General quality:			Patrimonial state:	
Best quality for water to be drunk ; guide value	25 mg/l	80	10 mg/l	Very good	10 mg/l	**Pristine or sub-natural** quality content; geochemical background; no detection of organics matters
Drinkable raw water (before the supply network); in many cases, the parametric value for human consumption	50 mg/l	60	25 mg/l	Good	25 mg/l	Anthropogenic **contamination** detected.
		40	50 mg/l	medium	37,5 mg/l	**Significative deterioration** from "natural" state
Undrinkable water	100 mg/l	20	100 mg/l	bad	50 mg/l	**Important deterioration** from "natural" state ;
Unsuitable water for a treatment to produce drinking water		0		very bad		**Very important deterioration** from "natural" state; contaminated sites cleanup

The groundwater quality assessment system SEQESO

- *each GQW threshold value is then converted into a general quality index (Ig) (interpolation lines and curves between 0, GQ1, GQ2, GQ3 and GQ4 points, and ∞)*

Drinking water use:		General quality:			Patrimonial state:	
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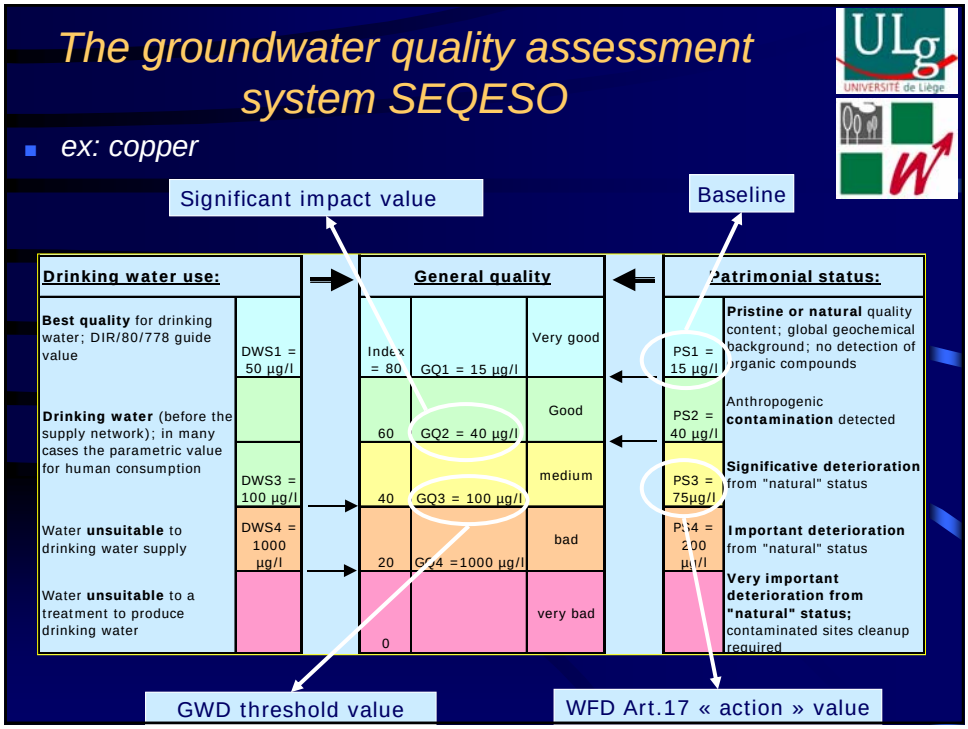
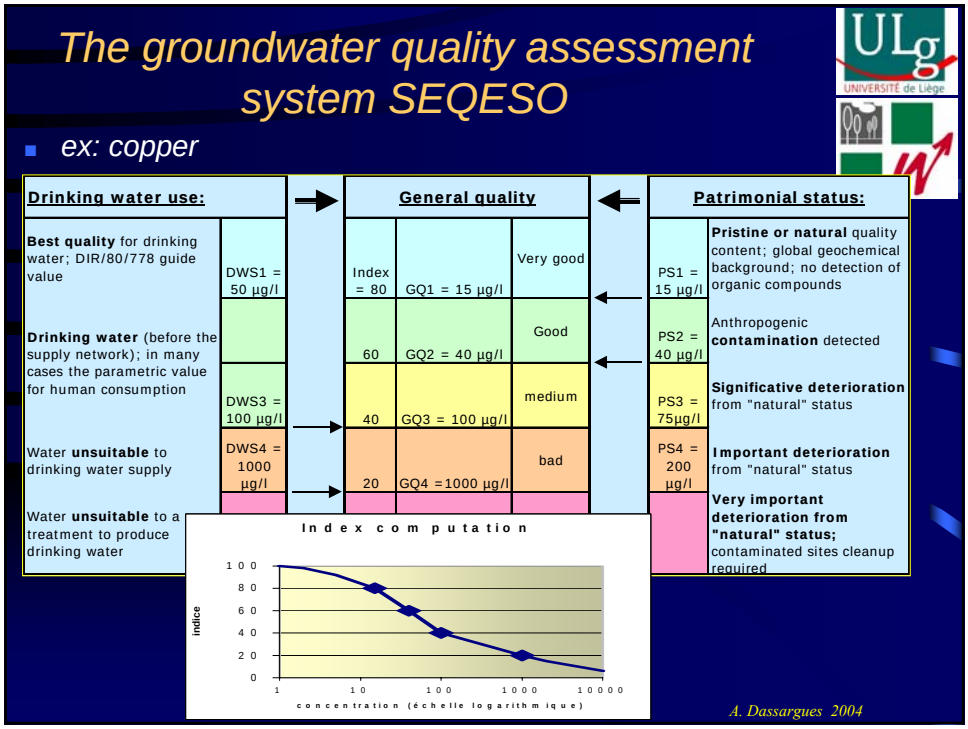
The groundwater quality assessment system SEQESO

- *ex: copper*



The groundwater quality assessment system SEQESO

- *ex: copper*



Application on which monitoring network ?

Network optimisation:

- *consider spatial representativity within each water body through scientific judgement (R index should reach 80 %)*
- *apply Eurowaternet density criteria: 1 site /25 km² under pressure, 1 site/100 km² otherwise;*
- *operate a selection from drinking water sites and add existing « patrimonial » sites to be monitored by DGRNE*
- *the total number of sites should normally decrease in the future*

but more important:

→ *select network points in function of an accurate and detailed knowledge of the actual hydrogeological conditions*

→ *detailed characterisation is needed !*

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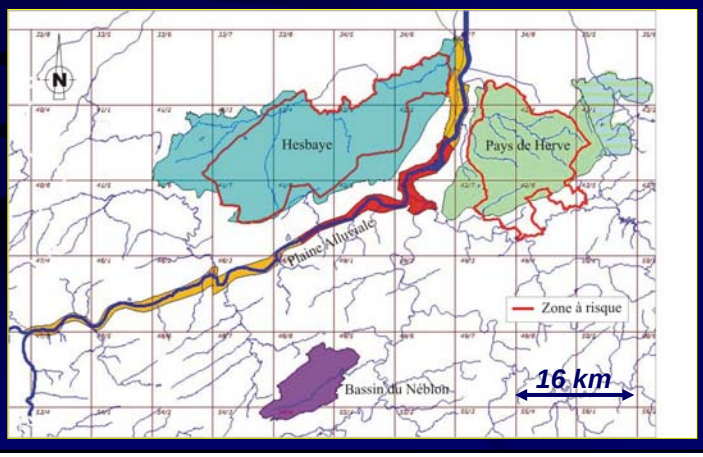
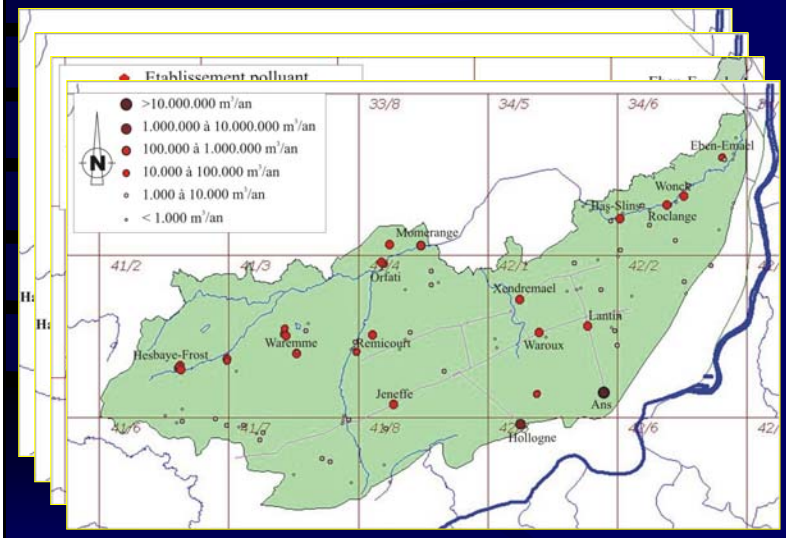
Application on which monitoring network ?

- *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*

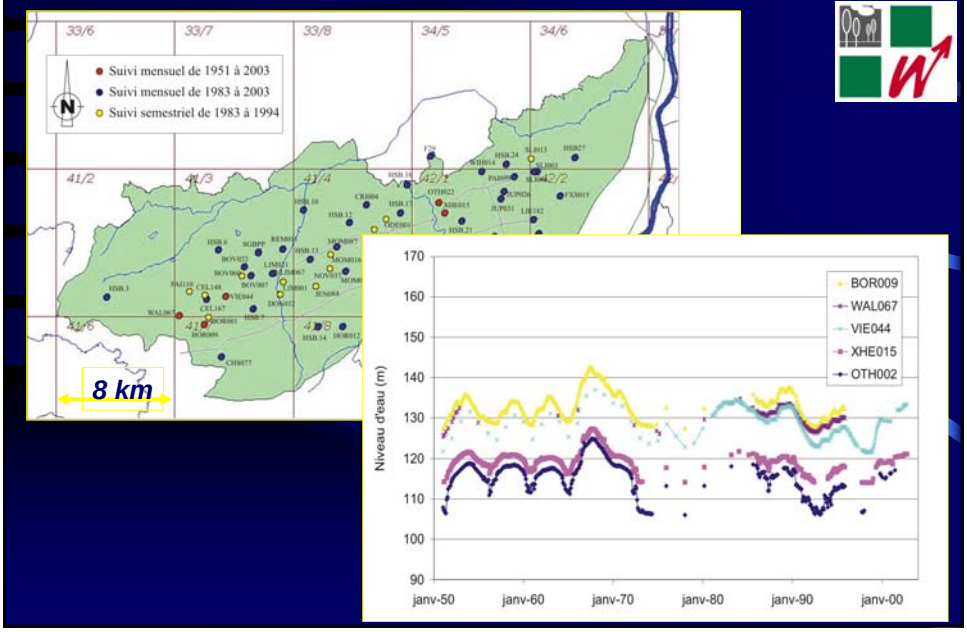


Optimisation of the monitoring network ?



collecting all existing data (quantity and quality)

Optimisation of the monitoring network ?



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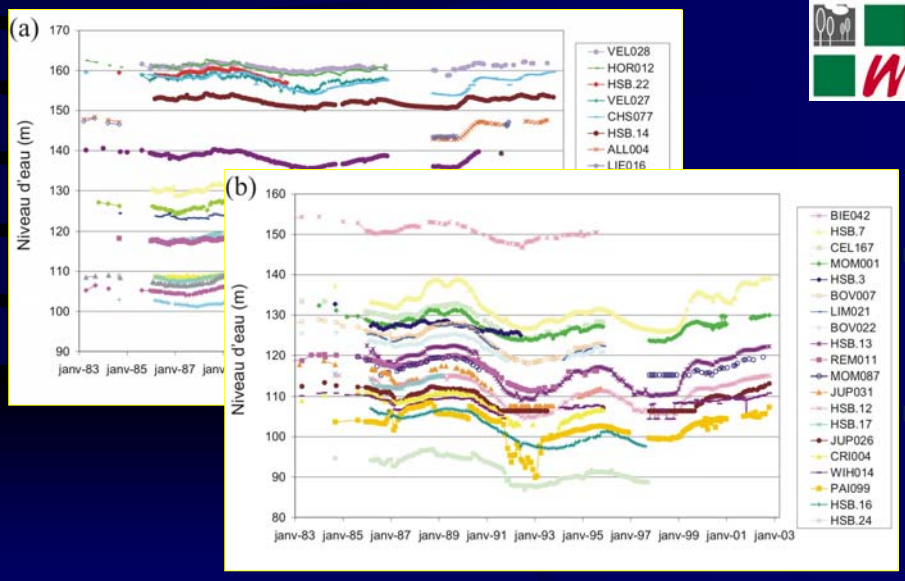

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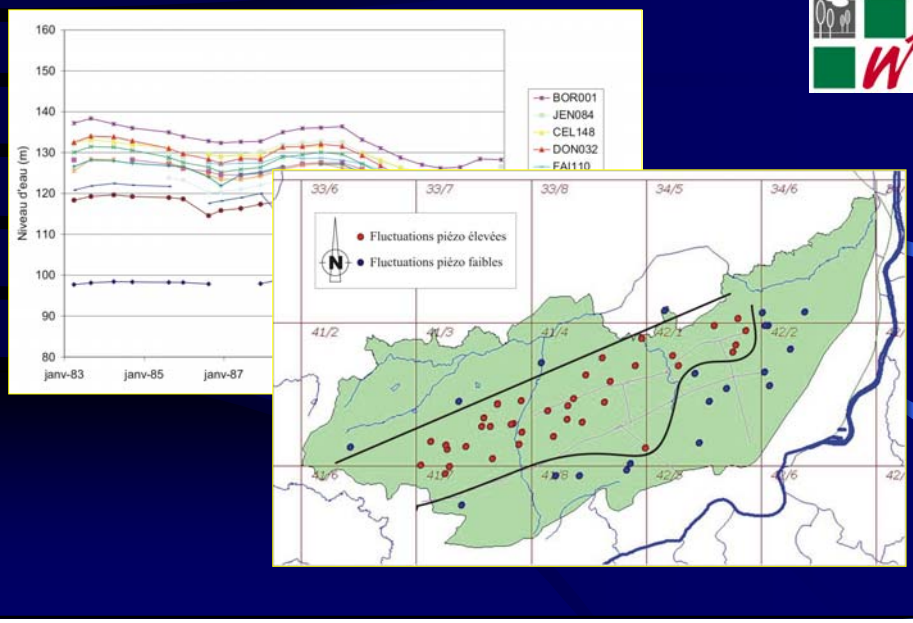

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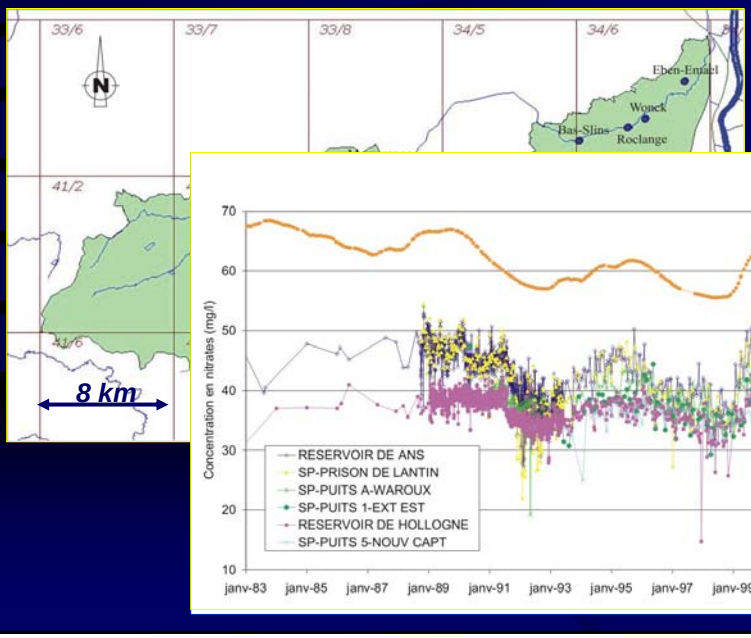


Optimisation of the monitoring network ?

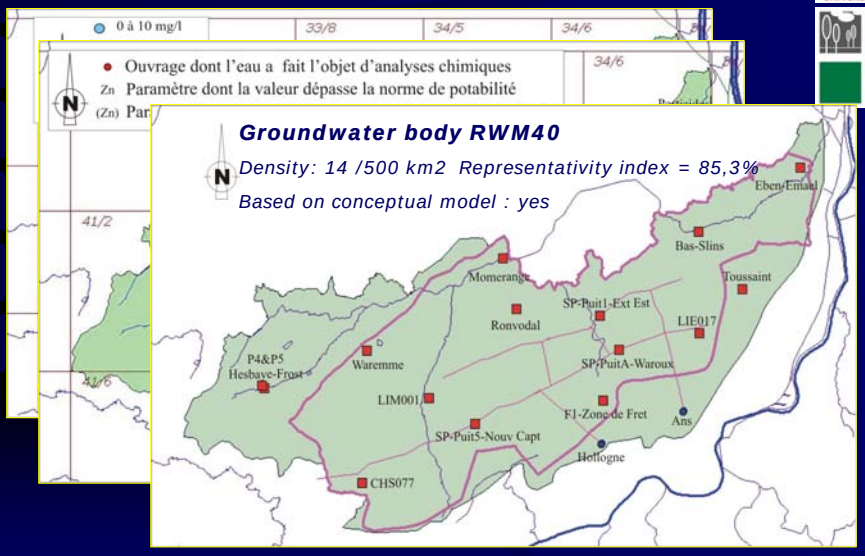
analysis of geological/hydrogeological conditions

➡ *choice of the points for the monitoring network*

…on the basis of few criteria:

- *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*
- *…*

Optimisation of the monitoring network ?



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

Aggregation of data ?

… a simple arithmetic mean as imposed by the directive ?

… arithmetic mean of what ?

two approaches in the SEQESO:

- *the "parameter aggregation"*
- *the "alteration aggregation"*

… practical method in four steps:

1. *an index I relative to every measured value is calculated*
2. *for each parameter, and for each water sampling point an arithmetic mean of index I over a considered period of time PMI (= Point Mean Index).*

Aggregation of data ?

Parameter aggregation

3. for each parameter, a BMI (Body Mean Index) is calculated averaging the PMI from the different points

→ index/parameter/gwbody

4. for each alteration, the minimum among the BMI is selected

→ index/alteration/gwbody

Alteration aggregation

3. for each monitoring network point, the minimum among the PMI of a given alteration is selected (PMA= Point Mean Alteration)

→ index/alteration/point

4. the PMA arithmetic mean over the monitoring network is calculated for each alteration

→ index/alteration/gwbody

Aggregation of data ?

Example: a monitoring network composed of 4 points (X1, X2, X3 et X4) and an alteration composed of 3 parameters (P1, P2 et P3)

All PMI obtained after the first 2 steps are given in the following table :

PMI	X1	X2	X3	X4
P1	82	85	19	75
P2	76	74	78	69
P3	54	42	55	40

Parameter aggregation

- index/parameter/gwbody

BMI(P1)=65 ; BMI(P2)=74 ; BMI(P3)=48

- index/alteration/gwbody

BMImin=48 (P3)

→ medium quality class (yellow) with P3 as the global problematic parameter

Alteration aggregation

- index/alteration/point

PMA(X1)=54 (P3) ; PMA(X2)=42 (P3) ; PMA(X3)=19 (P1) ; PMA(X4)=40 (P3)

- index/alteration/gwbody

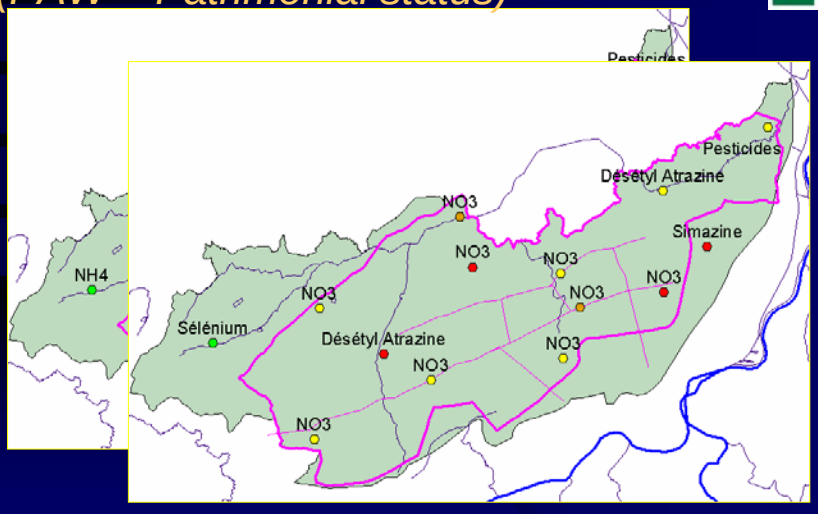
PMAmoy=39 (P1)

→ bad quality class (orange) with P1 as the local most problematic parameter

Discussion on the aggregation of data

- *results are similar when an alteration contains only one parameter, in all the other cases the second technique (alteration aggregation) is penalizing because it takes account of the worst situation*
- *the indicator calculated by this technique will always be smaller then the one calculated by the first technique*
- *the difference is accentuated if the points measurement variability is high*
- *the 'parameter aggregation' gives an insight of the global contamination problem, whereas the 'alteration aggregation' emphasizes a possible local contamination not necessarily representative of the GWBody*

Results of the SEQESO (ADE = Drinking water use) (PAW = Patrimonial status)



Results of the SEQESO : General Quality Index

SEQESO quality assessment system

Applied to: **RWM040 (chalks of the Geer basin)**

MONITORING SITES: **14** NUMBER OF ANALYSES: **2**

according to the parameter aggregation technique

ALTERATIONS (sets of parameters)

Mineralization (pH, hardness, Cl-, SO4--,...)

Nutrients and organic matter (N, P, TOC, ...)

Solids and filtrable matter (NTU, Fe, Mn, Al,...)

Mineral pollutants (Cu, Zn, As, B, CN-,Cd,...)

Pesticides (atracine, bromacil, diuron,...)

Other organic pollutants (TCE, HCB index,...)

General quality (GQW)

Ranking

very bad | bad | medium | good | very good

Index

0 20 40 60 80 100

"Global" quality

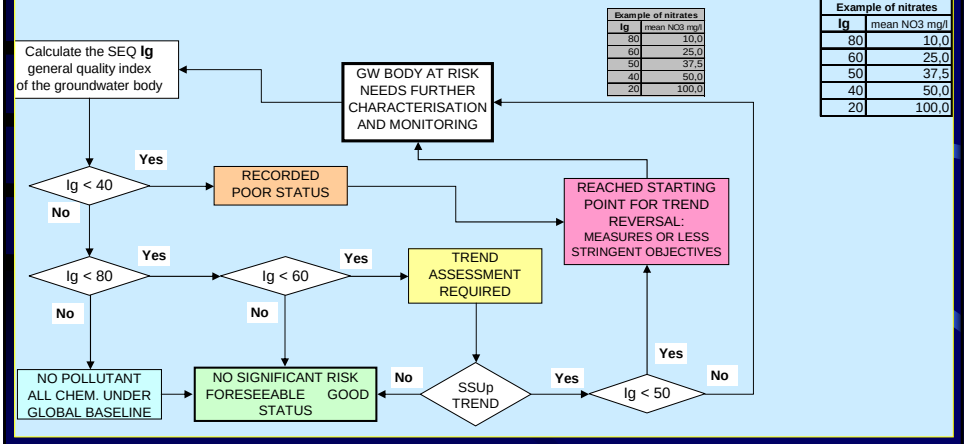
Water uses and functions

(with the most problematic parameter)

Drinking water supply (ADE)	Patrimonial Status (PAW)	Associated water courses (BIO)
Sulfates		
Nitrates	Nitrates	Nitrates
		Copper
Atracine	Atracine	DETatracine
Nitrates	Nitrates	Nitrates

the alteration is not relevent for the use

Decision tree: example



Example of nitrates	
Ig	mean NO3 mg/l
80	10,0
60	25,0
50	37,5
40	50,0
20	100,0

Examples of global evaluation

	GWBody	Quality class	Most problematic parameter	GWBody qualitative state
Cretaceous chalks of Hesbaye	RWM040	Medium (yellow)	Nitrates	"at risk"+ action threshold reached
Cretaceous chalks of Herve	RWM151	Medium (yellow)	Nitrates	"at risk"
Alluvial plain of the River Meuse (between Namur and Lanaye)	RWM072	Medium (yellow)	Sulfates	requires a trend analysis
Alluvial plain of the River Meuse (between Engis and Herstal)	RWM073	Bad (orange)	Manganèse	"at risk"+ action threshold reached
Carboniferous limestones of Néblon bassin	"RWM021"	Medium (yellow)	Nitrates	"at risk"

	Total	Very Good	Good	Medium	Bad	Very Bad
Drinking water points	743	8	135	367	212	21
Proportion	100,0%	1,1%	18,2%	49,4%	28,5%	2,8%
Other points	223	15	46	55	68	39
Proportion	100,0%	6,7%	20,6%	24,7%	30,5%	17,5%

Conclusions

- *SEQESO is a powerful tool to evaluate the chemical status of a groundwater body*
- *in accordance with the concepts of the Water Framework Directive and the subsequent proposal for a groundwater daughter directive*
- *representativity of the monitoring network … to be discussed*
- *aggregation techniques … to be discussed*
- *improvement possible for some parameters by taking more into consideration the BIO function, with the consequence of tightening the GQW thresholds*