Monitoring groundwater for the effectiveness of Action Programmes in Denmark

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Towards Sustainable groundwater in agriculture, june 2010

Geological Survey of Denmark and Greenland
Ministry of Climate and Energy

Lessons to learn

- Specifics on The Danish Groundwater Monitoring programme and Danish agriculture
- The conceptual models involved in the network design and the interpretation of results
- How time series gain value through groundwater dating

Setting the scene:

Facts about DK

43.000 km²

5.5 mill. people

2/3 agricultural land

100 % of drinking water comes from groundwater

coastal temperate climate

precipitation 600-1000 mm/yr

50-200 m thick Quaternary depositis

Setting the Scene:

Agriculture in DK the last 100 years

An important contribution to BNP

Increasing production since 1945

Increasing use of imported feed and artificial fertilisers

Increase in crop yields

Milk production increase from 4.000 to 10.000 from 1967-2007

Pig production increase from 11 to 19 mill. from 1967-2007

Setting the Scene:

Agriculture and the environmental measures National Action plans 1985 ff.

Restriction on the application and handling of N:

- Only sealed storage of manure
- Max. N-norms for specific crops
- Min. demand of utilisation of N content in manure

Results:

-Maintenance of crop yields

-40% decrease in N surplus

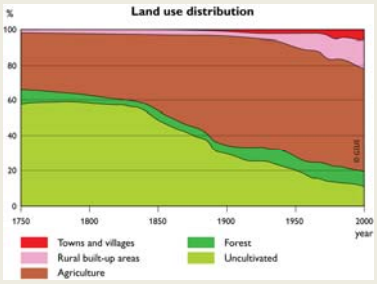
-Utilisation of N has increased from 20 to 38%

Pesticide action plans, with low impact due to voluntary measures

Phosphorus only indirectly regulated.

Land use in Denmark, mirrored in the monitored groundwater

- Groundwater of very different age is monitored.
- The monitoring is now focused on groundwater recharged after ~ 1950



The goals of the National Groundwater monitoring

- Meet the EU demands for monitoring in the Nitrates and Water Framework directive
- Asses the status of groundwater quality for aquifers relevant for groundwater production and in the future also surface waters.
- Identify effects of national actions plans
- Identify trends of quality deterioration (WFD)
- Identify Quantitative state and trends (WFD)

The National monitoring networks. Large scale monitoring

Initiated in 1988. Revised every 6th year.
Covers water and air

Groundwater specifics:

74 groundwater monitoring areas

~ 1600 screens, analysed once every year

5 Agricultural Catchment Areas

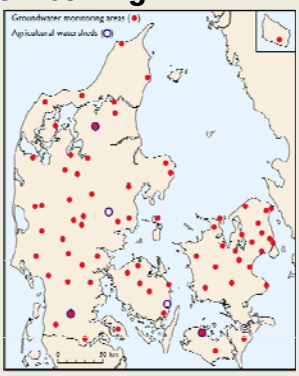
~ 100 screens, analysed 4 times every year

Groundwater level monitoring

~ 125 screens, continuous logging

10.000 abstraction wells

Results from the periodically control (every 3rd- 5th year) in all water works wells financed by waterworks.



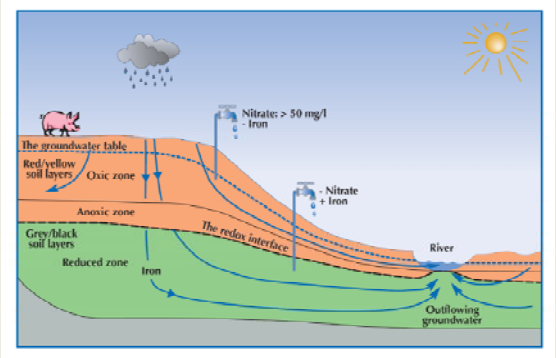
Chemical analysis
The national groundwater monitoring

- Main chemical substances
  - Nitrate, sulphate, chloride, calcium, pH etc.
- Pesticides and metabolites (up to 46)
  - atrazine, metribuzine, bentazone, MCPA..
- Inorganic trace elements (up to 24)
  - Ni, As, Hg, Cu, Zn, Al, B, Co
- Organic pollutants (up to 45)
  - Solvents, detergents, BTEX, nonylphenolic etc
- CFC, ^3H for dating purposes.

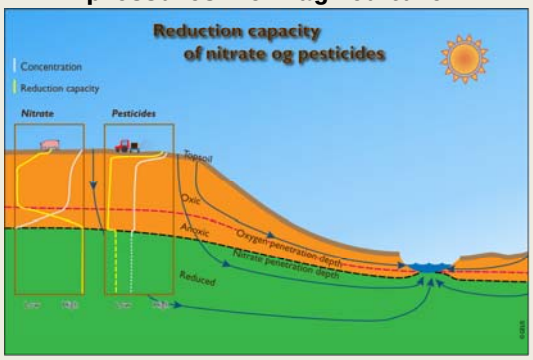
The need of conceptual Models

- Prerequisite for monitoring strategy, choice of parameters design and interpretations
  - Chemical state and dynamics esp. nitrate and pesticides
  - Nitrate vulnerability
  - The main type of aquifers and their chemical dynamics
- **5D understanding of the system:**
  Every measurement represents a (x,y,z,t_r,t_s).
  - (x,y,z) as the location of the filter,
  - t_r date of groundwater recharge,
  - t_s the date of sampling.

The classic conceptual model for nitrate in groundwater



Conceptual models for understanding pressures from agriculture.



NOTE: Nitrate and pesticides have different dynamics!

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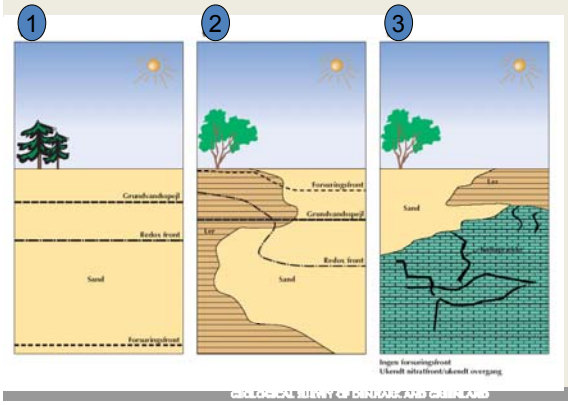
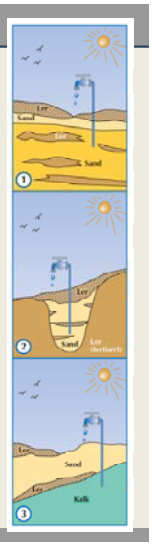
Conceptual model for natural condition

The redox interface (nitrate penetration depth)

and the acidification interface





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Results

- Trends and the benefit of dating
- Individual filters and populations

Local and national scales

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Tren filters.

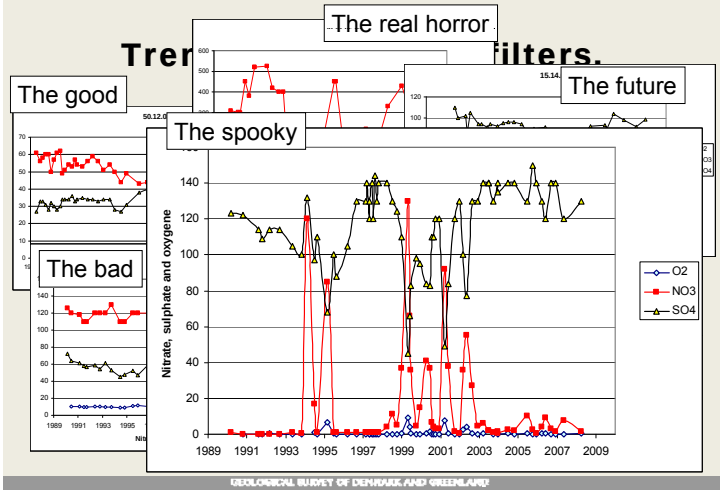
The real horror

The good

The future

The spooky

The bad



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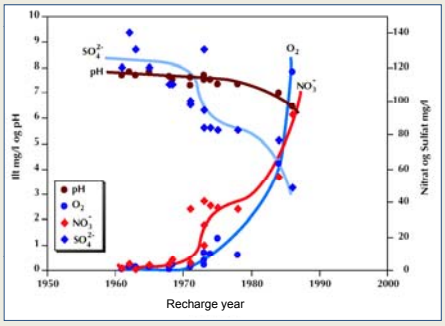
CFC-dating as a tool for better understanding of trends

$t_s \rightarrow t_r$



The sampling date is transformed to ”year of recharge” by CFC-dating
Nitrate reduction and age can explain the variations

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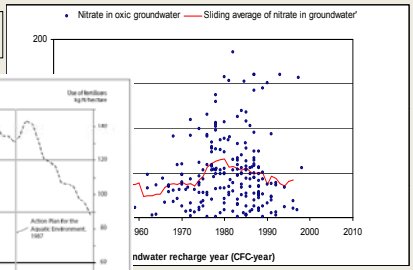
Nitrate at national scale shows a overall decrease, using CFC-age as timescale.

217 oxic filters
5 years floating mean



All data, with a geochemical model

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Key Consequences

- The action plans seems to improve groundwater quality.
  - More tricky on a national scale than on the local scale, due to immanent LARGE variations
- Conceptual models must be used to evaluate the environmental impact of the measures taken.
- Be ware of the 5D character of monitoring data, when using data in 2D presentations as maps, timeseries etc.
- Groundwater dating is indispensable, for strong and fast interpretation of trends.
- The business of monitoring resembles foresting; the value of investment rises with time, and the short time return is low.
  - Monitoring systems must be conservative.

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