

## Indicator Fact Sheet

### (WEU1) Nitrate in groundwater

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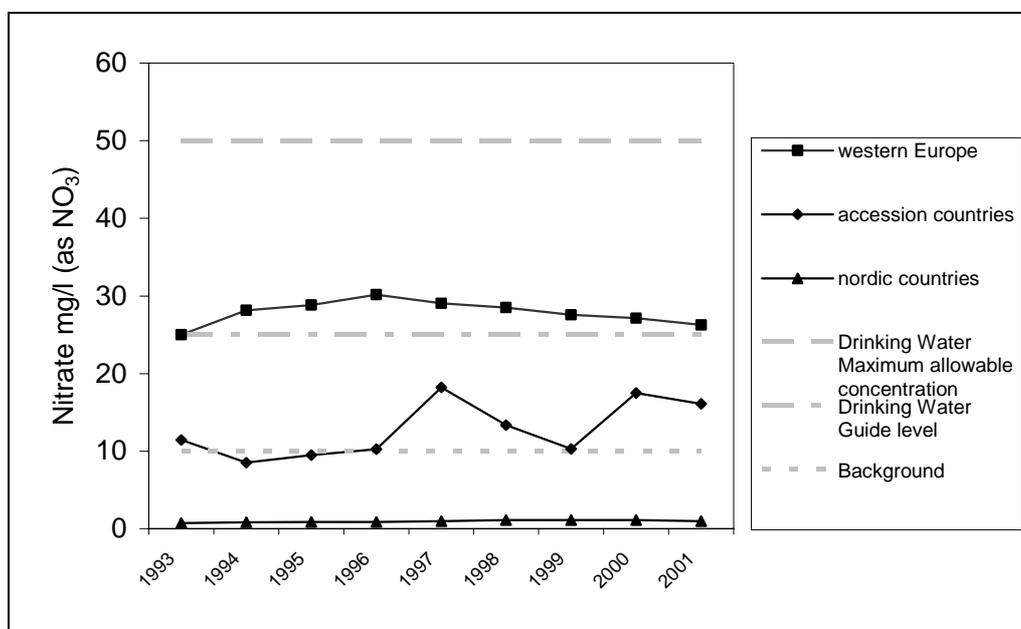
EEA project manager: Niels Thyssen

Indicator code / ID	WEU1
Analysis made on (Assessment date)	11 May 2004
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#### Key message

☺ There is no evidence of a decrease (or increase) of nitrate concentrations in Europe's groundwaters.  
Nitrate drinking water limit values are exceeded in around one-third of the groundwater bodies for which information is currently available.

**Figure 1: Temporal development of nitrate (arithmetic) mean values in groundwater bodies from 1993 to 2001**



Note: The figure shows the time series 1993-2001. It compares mean values for Western Europe, the Accession countries and the Nordic countries.

Western Europe: Austria, Belgium, Denmark, Germany, Netherlands; 34 GW-bodies

Accession countries: Bulgaria, Estonia, Hungary, Lithuania, Slovenia; 39 GW-bodies

Nordic countries: Finland, Norway; 21 GW-bodies; Swedish data are not included due to a data gap

The Drinking Water guide level is laid down in the Drinking Water Directive 80/778/EC. This Directive is repealed with effect from five years after the entry into force of Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. In the new Drinking Water Directive 98/83/EC a Drinking Water Guide level is no longer mentioned.

The time series consist of consistent data sets with no data gaps. For each time series the annual mean values of sampling sites were aggregated on the level of GW-bodies and, furthermore, these GW-body means were aggregated on European level (arithmetic mean).

Source: WATERBASE data collected through EUROWATERNET.

## **Results and assessment**

### Policy relevance:

The Nitrates Directive (91/676/EEC) aims to control nitrogen pollution and requires Member States to identify groundwaters that contain more than 50 mg/l nitrate or could contain more than 50 mg/l nitrate if preventative measures are not taken. In addition, the Drinking Water Directive (98/83/EC) sets the maximum allowable concentration for nitrate of 50 mg/l. It has been shown that drinking water in excess of the nitrate limit can result in adverse health effects, especially in infants less than two months of age. Groundwater is a very important source of drinking water in many countries and it is often used untreated particularly from private wells.

### Policy context:

The indicator aims to show whether the pollution from nitrogen is decreasing.

One key approach of the Sixth Environment Action Programme of the European Community 2001-2010 is to "integrate environmental concerns into all relevant policy areas" which could result in a more intense consideration of this issue (e.g. in the Common Agricultural Policy).

The Nitrates Directive sets a limit for the amount of livestock manure applied to land each year, including by the animals themselves, of 170 kg N per hectare.

### Environmental context:

Agriculture is the largest contributor of nitrogen pollution to groundwater as nitrogen fertilisers and manure are used on arable crops to increase yields and productivity. In the EU mineral fertilisers account for almost 50 % of nitrogen inputs into agricultural soils and manure for 40 % (other inputs are biological fixation and atmospheric deposition) [1]. According to the indicator on the use of fertilisers, nitrogen fertiliser consumption (mineral fertilisers and animal manure) increased until the late 1980s and then started to decline but in recent years it has increased again in the EU and EFTA countries. Nitrogen fertiliser consumption per hectare of arable land is higher in the EU and EFTA countries than in the Accession countries.

Nitrogen from excess fertiliser percolates through the soil and is detectable as elevated nitrate levels under aerobic conditions and as elevated ammonium levels under anaerobic conditions. The rate of percolation is often slow and excess nitrogen levels may be the effects of pollution on the surface up to 40 years ago depending on the hydrogeological conditions.

A further indicator on the nitrogen balance in agricultural soils indicates that there is a large nitrogen surplus in the agricultural soils of EU countries that can potentially pollute groundwaters [7]. Furthermore, a high potential for nitrogen pollution in Western Europe results from the combination of high percentage of agricultural land and a high livestock density [6].

### Assessment:

Mean nitrate concentrations in groundwaters in Europe are above background levels (<10 mg/l as NO<sub>3</sub>) (EEA, 2000) but do not exceed 50 mg/l as NO<sub>3</sub>. Due to a very low level of mean nitrate concentrations (<2 mg/l as NO<sub>3</sub>) in the Nordic countries the European mean nitrate concentration shows a biased view for nitrate. Hence the presentation is separated into Western Europe, Nordic Countries and Accession Countries. In Western Europe the mean nitrate concentrations in groundwaters are above the Drinking Water Guide level (> 25 mg/l as NO<sub>3</sub>). Further details are shown in Sub-indicator 1. Additional information has to be taken into account (see Sub-indicators) for the interpretation of the figures as they may have a strong influence on the quality data provided (e.g. type of GW-bodies and type of monitoring sites).

According to the latest European Commission report [1] there is a high and stagnant level of nitrate concentrations in groundwater. The general trend in nitrate concentrations in groundwater when comparing the first (1992–1994) and second (1996–1998) monitoring exercise is summarised as "stable to increasing". Countries showing an overall increase in nitrate concentrations in groundwater are France and Sweden [1].

It is very difficult to prove a direct context between the application of nitrogen fertiliser in agriculture and the nitrate content in groundwaters as there is often a significant time lag between changes in agricultural practices and changes in nitrate concentrations in groundwater of up to 40 years, depending on the hydrogeological conditions [4].

The map of nitrate problem areas in EEA (2000) and statements in several State of the Environment (SoE) reports indicate that the provided information might not fully reflect problems with nitrate in groundwater in Europe as several nitrate problem areas mentioned in the SoE reports are not reported to EUROWATERNET.

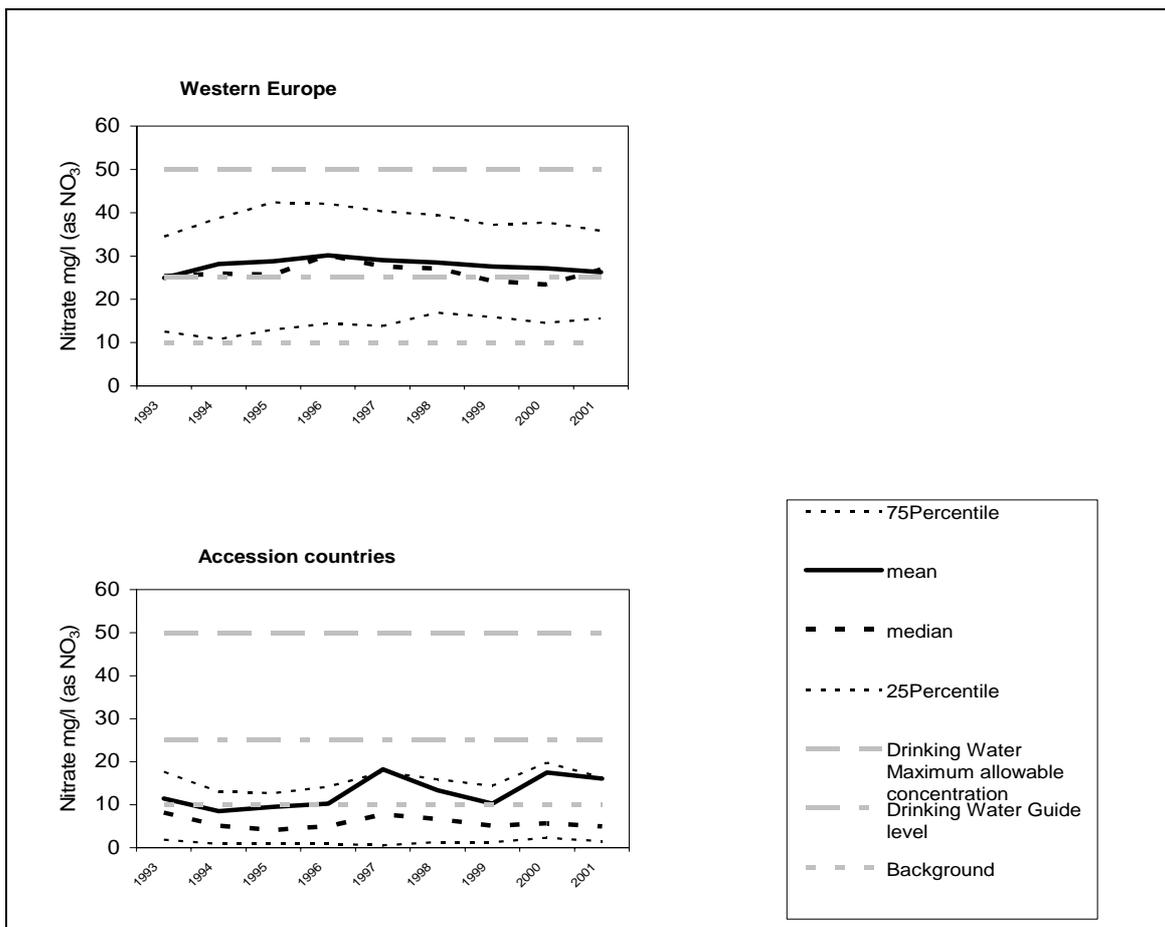
Furthermore, low nitrate concentration levels can occur due to reducing conditions. Therefore the Sub-indicator 6 on ammonium has been introduced to provide complementary information.

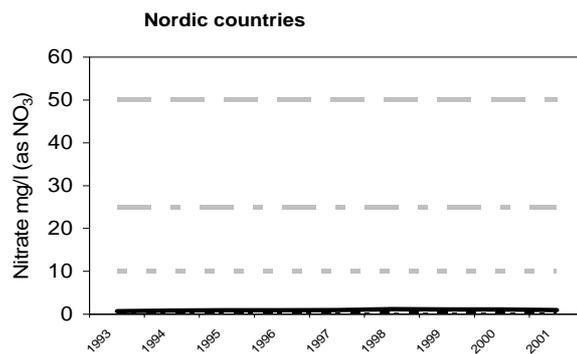
### Sub-indicator 1

### Temporal development of nitrate (arithmetic) mean values in groundwater bodies under regional aspects from 1993 to 2001

#### Key message

☺ Nitrate concentrations in groundwaters have remained relatively stable since the 1990s and are highest in Western Europe.





Note: The figure shows the time series 1993-2001. It compares 25Percentile, median, mean and 75Percentile.

Western Europe: Austria, Belgium, Denmark, Germany, Netherlands; 34 GW-bodies

Accession countries: Bulgaria, Estonia, Hungary, Lithuania, Slovenia; 39 GW-bodies

Nordic countries: Finland, Norway; 21 GW-bodies; Swedish data are not included due to a data gap

The Drinking Water guide level is laid down in the Drinking Water Directive 80/778/EC. This Directive is repealed with effect from five years after the entry into force of Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. In the new Drinking Water Directive 98/83/EC a Drinking Water Guide level is no longer mentioned.

The time series consist of consistent data sets with no data gaps. For each time series the annual mean values of sampling sites were aggregated on the level of GW-bodies and, furthermore, these GW-body means were aggregated on European level (arithmetic mean). Percentiles are calculated based on annual mean values of sampling sites aggregated on the level of GW-bodies.

Source: WATERBASE data collected through EUROWATERNET.

### Assessment of the Sub-indicator

The annual mean nitrate concentrations in groundwaters have remained relatively stable since the 1990s but show different levels of concentration regionally.

The high nitrate concentration in Western Europe (AT, BE, DK, DE, NL) can be seen as consequence of the intensive agriculture and the coherent usage of nitrogen fertilisers.

The temporal development of the total nitrogen fertiliser consumption within these regions and the regional differentiation in levels is very similar and relatively stable as well (Dataservice: Fertiliser consumption). But not only the consumption figures are high in Western Europe, but also the usage per hectare of agricultural land. In 1994 NL, DK, BE, DE were amongst the five countries with the highest nitrogen fertiliser usage related to the agricultural area. In Finland (11.) and Norway (4.) the nitrogen fertiliser usage is also high but the agricultural area represents only 9 respectively 3 % of the total land area. Although the agricultural area in the Accession countries ranges between 60 and 80 % of the total land area the agricultural practice is of less intensity than in Western Europe. The nitrate fertiliser usage per agricultural land area is about one quarter of that in Western Europe (EEA, 2000).

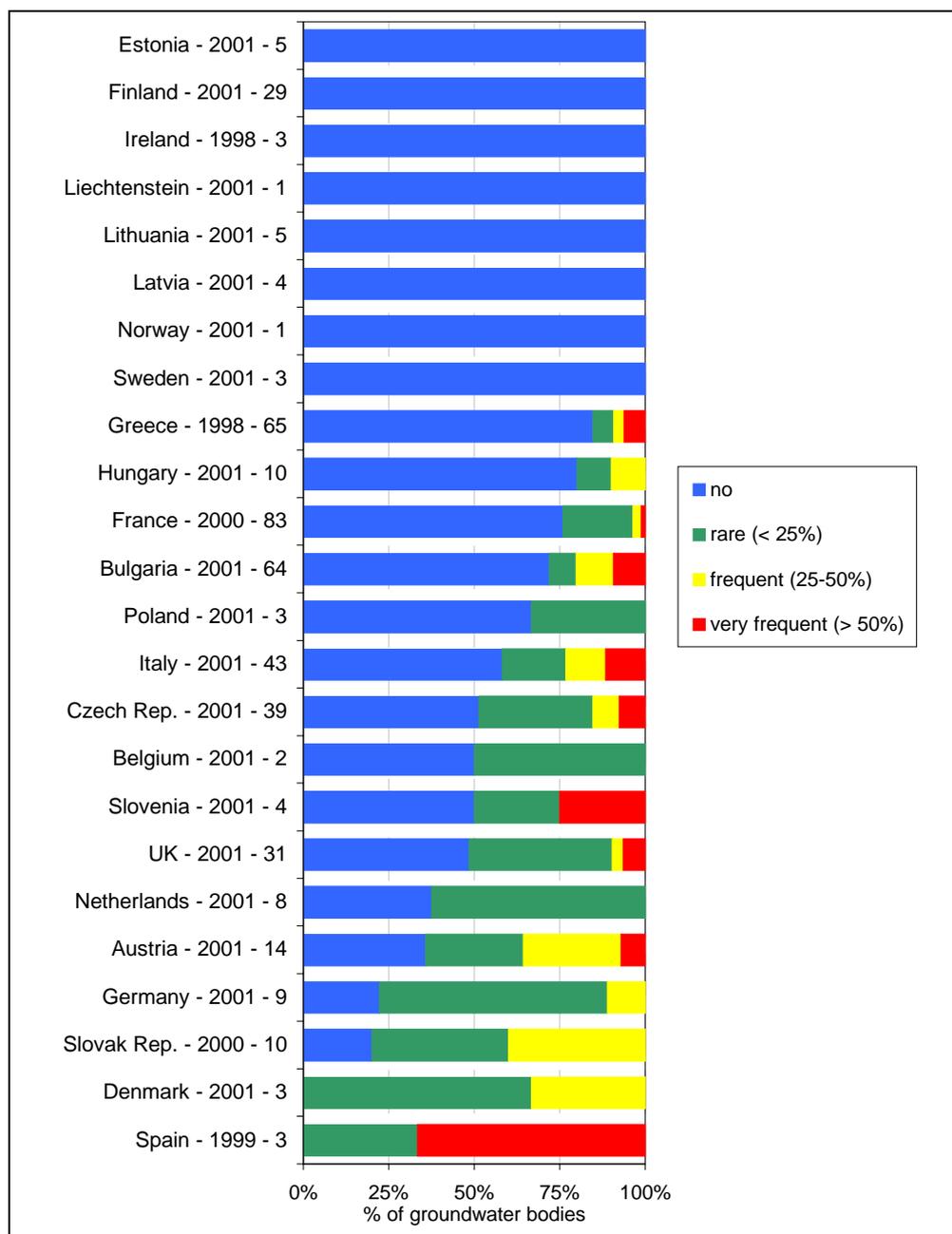
It might be supposed that if the agricultural practice is intensified in the Accession countries then the nitrate concentration in groundwaters might rise. But it is very difficult to prove a direct context between the application of nitrogen fertiliser in agriculture and the nitrate content in groundwaters as there is often a significant time lag between changes in agricultural practices and changes in nitrate concentrations in groundwater of up to 40 years, depending on the hydrogeological conditions [4].

## Sub-indicator 2

### Percentage of sampling sites in groundwater bodies where annual mean values exceed 50 mg/l nitrate

#### Key message

○ Nitrate drinking water limit values are exceeded in around one-third of the groundwater bodies for which information is currently available.



Note: The figure is based on the data for the latest year available (given after the country name). The numbers of groundwater bodies per country included in the presentation are given after the year. The four classes represent the percentage of sampling sites within each groundwater body where annual mean nitrate values exceed 50 mg NO<sub>3</sub>/litre (parametric value according to the Drinking Water Directive 98/83/EC).

Source: WATERBASE data collected through EUROWATERNET..

### Assessment of the Sub-indicator

The annual mean nitrate concentration in at least one sampling site in about one third of the groundwater-bodies (included in EUROWATERNET) exceeds 50 mg/l nitrate. Values higher than 50 mg NO<sub>3</sub>/l were detected frequently or very frequently in 56 groundwater-bodies (13 %).

According to the latest European Commission report [1] 20 % of EU stations had concentrations in excess of the maximum allowable concentration (50 mg/l as NO<sub>3</sub>) and 40 % were in excess of the guide value in the Drinking Water Directive (25 mg/l as NO<sub>3</sub>) in 1996–1998.

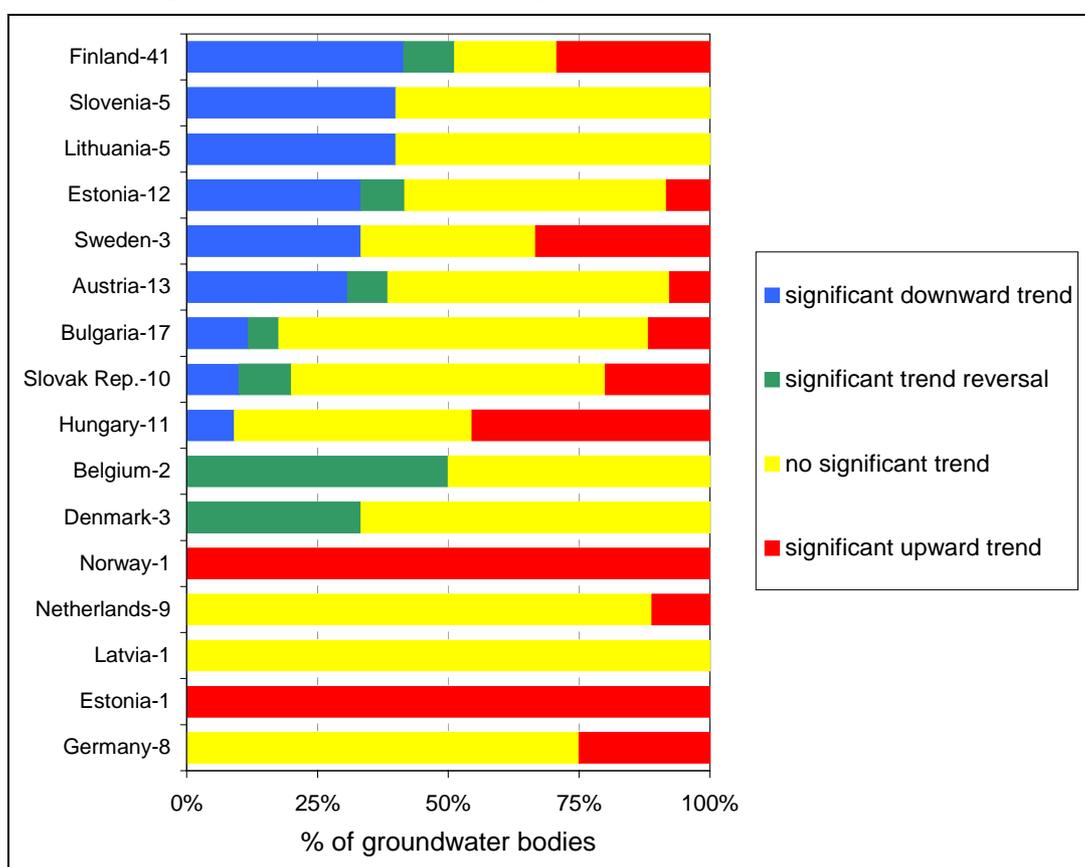
### Sub-indicator 3

#### Statistically significant trends for nitrate

##### Key message

○ The temporal development of nitrate in groundwater demonstrates no substantial improvement. In 31 % out of 142 GW-bodies a statistically significant downward trend or a trend reversal could be proved, for about 49 % of the GW-bodies no improvement could be stated and for 20 % of the GW-bodies even an upward trend was proved.

#### Statistically significant trends for nitrate in groundwater bodies



Note: The figure is based on the latest years available. The number of assessed groundwater bodies is given after the country name. In general, assessment for time series as long as possible, but minimum /maximum length of time series for trend assessment (LOESS-smoother) = 8 years / 15 years, minimum /maximum length of time series for trend reversal assessment (2-section model) = 14 years / 30 years. Missing of one value within a time series was accepted.

Trend assessment was performed by the LOESS smoother, trend reversal was assessed by the 2-section model, both as proposed by Working Group 2.8 of the Common Implementation Strategy of the EC for the Water Framework Directive (<http://www.wfdgw.net>). In order to be in line with the WFD the presentation of this indicator will be modified as soon as the specifications are laid down in the Groundwater Directive.

Additional information on the algorithms as well as on the project is available at [www.wfdgw.net](http://www.wfdgw.net)

Source: WATERBASE data collected through EUROWATERNET; Algorithm: <http://www.wfdgw.net>, 2001.

**Assessment of the sub-indicator**

The results of the trend assessment together with the temporal development of nitrate mean values demonstrated in the main indicator do not allow for an optimistic view. When interpreting trend developments, the often significant time lag between changes in agricultural practices and changes in groundwater quality has to be kept in mind.

Due to this time lag which might be significant (up to 40 years) and which is depending on the individual hydrogeological conditions of the GW-body there is no rule when changes in the nitrate concentrations in groundwater as a result of changes in agricultural practice can be expected. Some of the indicated upward trends might, for example, be caused by intensification measures in agricultural practice set 20 years ago. The actual cause effect relationship has to be assessed individually for each GW-body. Nevertheless, it is an indication that remediation and improvement measures have to be implemented over medium or rather long term in order to break or even reverse upward trends.

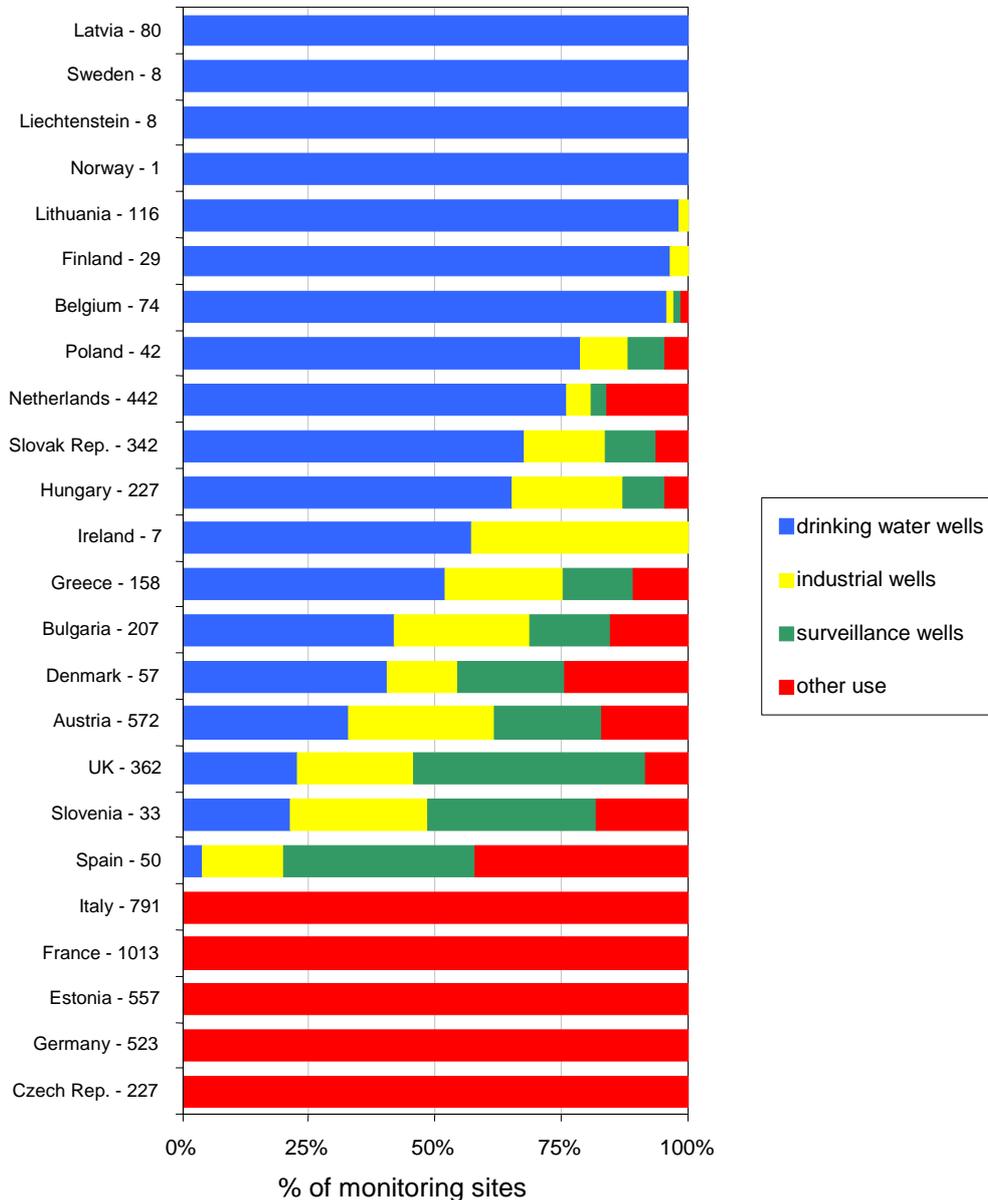
## Sub-indicator 4

### Type of monitoring sites for nitrate

#### Key message

🕒 In several countries sampling sites used for drinking water supply (showing rather good GW-quality) are dominating.

#### Type of monitoring sites for nitrate in groundwater



Note: Share of types of groundwater monitoring sites in %. The number of monitoring sites is given after the country name. Assessment is for the latest year available (corresponding to the status assessment of the main indicator). There is no information on type provided for the sites of CZ, DE, EE, FR and IT. Therefore these sites are attributed to other use. They represent 52% of all monitoring sites.

Source: WATERBASE data collected through EUROWATERNET..

#### Assessment of the sub-indicator

The type of use of the sampling site may have a strong influence on the monitored GW-quality, which has to be considered when making comparisons and assessments. The guidelines of

EUROWATERNET recommend a "balanced spatial distribution as well as balanced mixture of different types of sampling sites" and countries are encouraged to keep this in mind.

Unfortunately in many countries the predominating type of sampling sites is for drinking water purposes. As drinking water wells are usually situated in GW-bodies with rather higher quality, the overall situation of groundwater quality might be biased.

But nevertheless, EUROWATERNET is based on already available information and in many countries groundwater monitoring is not that developed and relies on the existing drinking water network. With the implementation of the Water Framework Directive, where groundwater monitoring is required, the representativity of the selection of monitoring sites is supposed to improve.

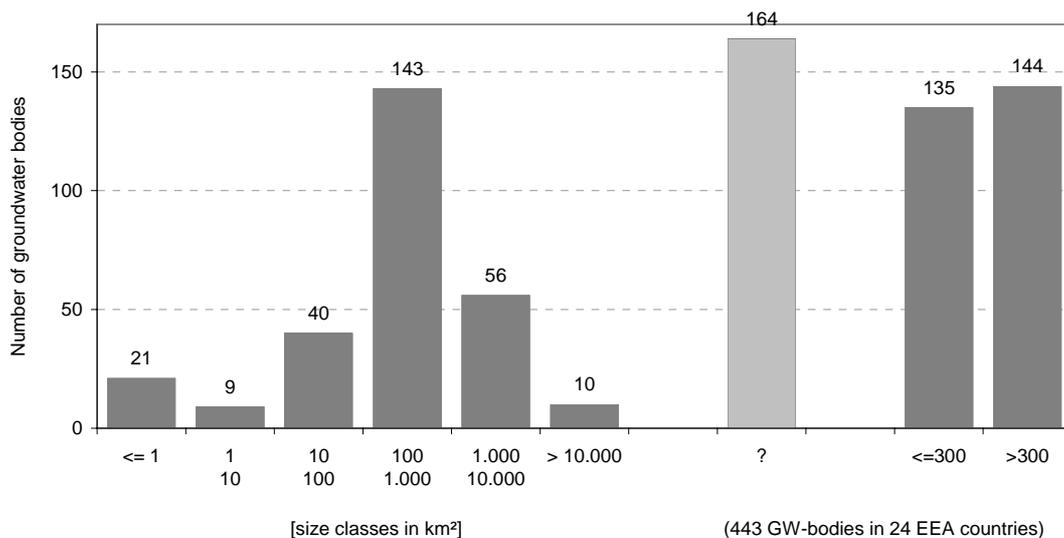
## Sub-indicator 5

### Number of GW-bodies with information on nitrate and size categories

#### Key message

Groundwater quality information on nitrate is based on a broad variety of groundwater bodies with regard to the distribution of size and types.

#### Number of groundwater bodies with information on nitrate according to size categories



Source: WATERBASE data collected through EUROWATERNET.

#### Assessment of the sub-indicator

About one third of the GW-bodies where nitrate information is available have a size between 100 and 1 000 km². Furthermore, about one third of the GW-bodies with nitrate data are smaller than or equal to 300 km² which means that they are of regional, socio-economic or environmental importance in terms of quantity and quality or exposed to severe or major impacts according to the selection criteria of the EUROWATERNET guidelines. For 164 (37 %) GW-bodies size information is not available.

## Sub-indicator 6

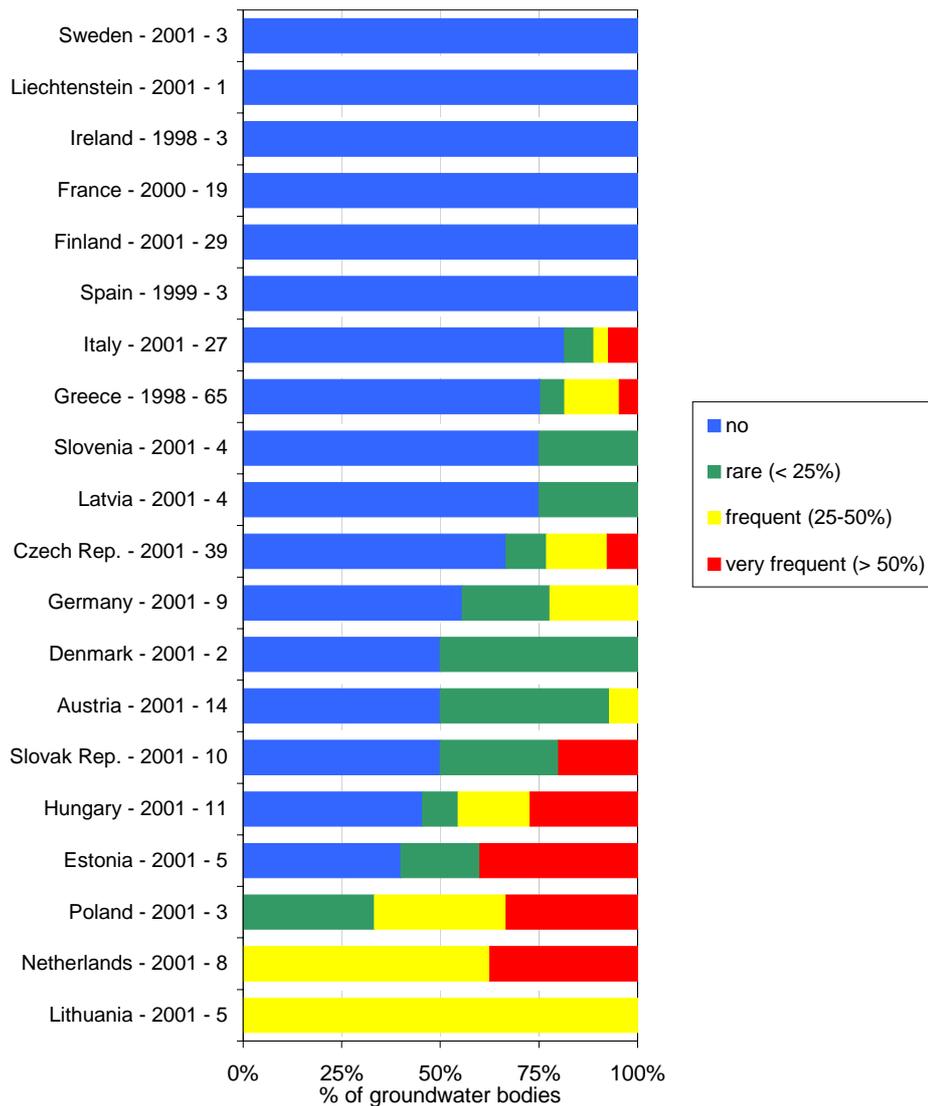
### Ammonium in Groundwater

#### Key message

○ The chart indicates that in around 30 % of the GW-bodies, where information is available, the parametric value of ammonium (0.5 mg/l) is exceeded.

### Ammonium in Groundwater

#### Status - latest year available



Note: The figure is based on the data for the latest year available (given after the country name). The numbers of groundwater bodies per country included in the presentation are given after the year. The four classes represent the percentage of sampling sites within each groundwater body where annual mean ammonium values exceed 0.5 mg NH<sub>4</sub>/litre (the parametric value according to the Drinking Water Directive 98/83/EC).

Source: WATERBASE data collected through EUROWATERNET.

**Assessment for the sub-indicator**

In case of reducing conditions, nitrogen can also be present in groundwater in the form of ammonium. The occurrence of ammonium can be due to natural conditions but also indicate pollution of groundwater. The indicator on ammonium shows 78 out of 264 groundwater bodies with an ammonium concentration above the parametric value, even if in several of these groundwater bodies the nitrate concentration is around the background concentration. The level of the parametric value of ammonium serves as indicator of faecal contamination of the groundwater.

At about 30 % of the GW-bodies at least one sampling site exceeds the parametric value of 0.5 mg/l ammonium by its annual mean value. Values higher than 0.5 mg NH<sub>4</sub>/l were detected frequently or very frequently at 51 GW-bodies (19 %).

## Sub-indicator 7

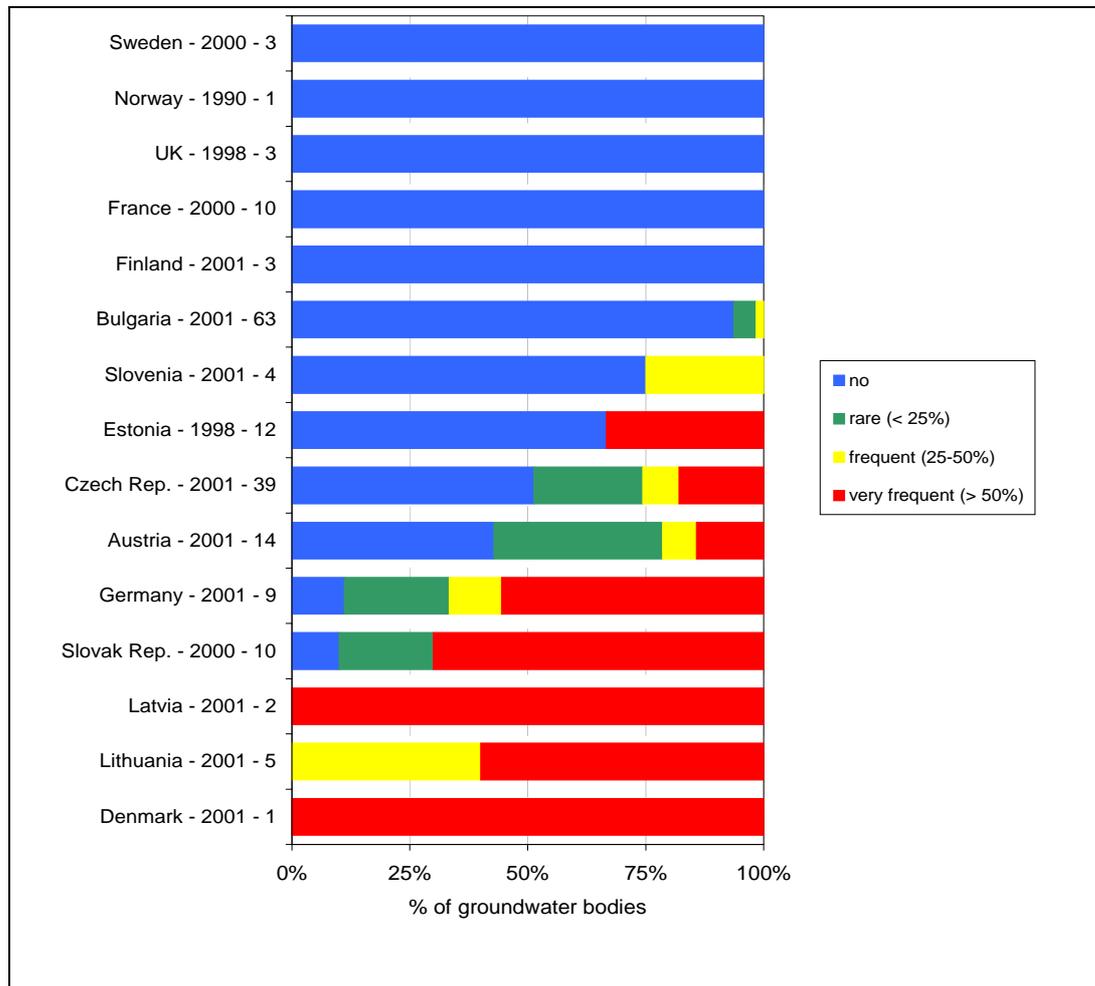
### Dissolved Oxygen in Groundwater

#### Key message

○ Dissolved oxygen in groundwater is a supportive determinand for assessing nitrogen pollution. Information is rather scarce. In several countries the level of dissolved oxygen concentration is rather low which indicates that nitrogen pollution might not only be evident by nitrate but also by nitrite and ammonium.

#### Dissolved oxygen in Groundwater

##### Status - latest year available



Note: The figure is based on the data for the latest year available (given after the country name). The numbers of groundwater bodies per country included in the presentation are given after the year. The four classes represent the percentage of sampling sites within each groundwater body where annual mean dissolved oxygen values are below 2 mg O<sub>2</sub>/litre.

Source: WATERBASE data collected through EUROWATERNET..

#### Assessment of the sub-indicator

Inorganic nitrogen compounds are transformed under presence of oxygen and nitrifying bacteria. Ammonium is transformed into nitrite and nitrate under oxygen demand. Concentration

of dissolved oxygen in groundwater might give supportive information on the stage of nitrogen transformation and whether nitrogen pollution is evident as ammonium, nitrite or nitrate.

At about one-third of the GW-bodies at least one sampling site falls below 2 mg/l dissolved oxygen by its annual mean value. Values below 2 mg O<sub>2</sub>/l were detected frequently or very frequently at 40 GW bodies (22 %).

The suspicion of nitrogen contamination in groundwater can only be rejected if the nitrate concentration is proven to be low and the dissolved oxygen concentration is considerably above 2 mg/l, otherwise nitrogen contamination might be present as ammonium or nitrite contamination.

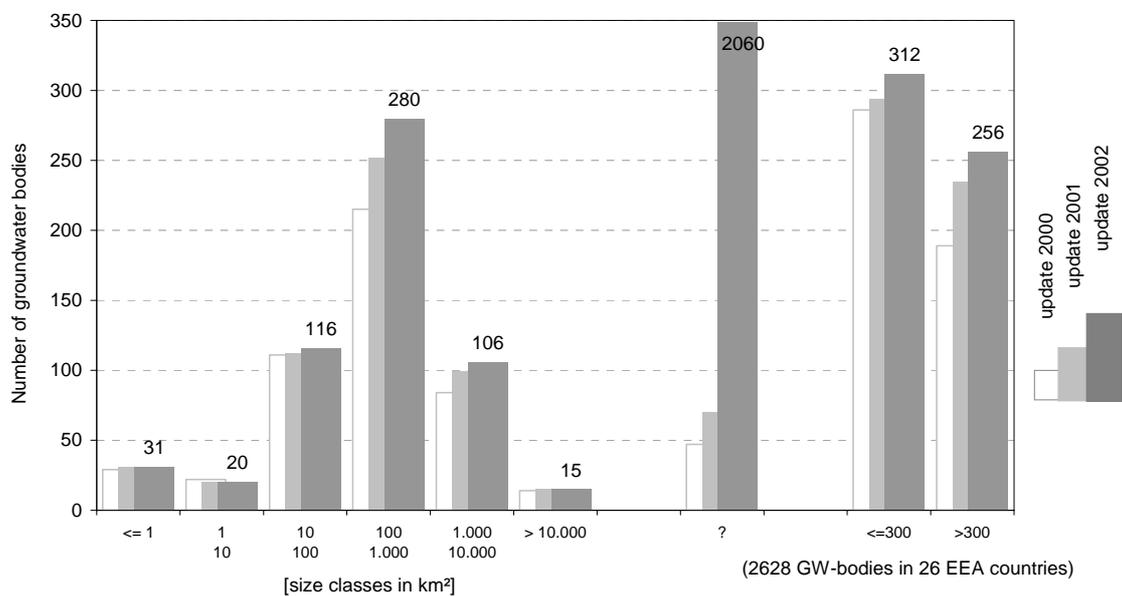
## Sub-indicator 8

### Number of GW-bodies and size categories within EUROWATERNET-Groundwater

#### Key message

🕒 EUROWATERNET-Groundwater is based on a broad variety of groundwater bodies with regard to the distribution of size. There was a substantial improvement in the amount of information which is currently available for European-wide groundwater quality assessments with regard to nitrate, nitrite, ammonium and dissolved oxygen.

#### Total number of groundwater bodies within EUROWATERNET-Groundwater according to size categories



Source: WATERBASE data collected through EUROWATERNET.

#### Assessment of the sub-indicator

About half of the GW-bodies of EUROWATERNET with information on size belong to the class between 100 and 1 000 km<sup>2</sup>. About half of the GW-bodies are smaller than or equal to 300 km<sup>2</sup> which means that they are of regional, socio-economic or environmental importance in terms of quantity and quality or exposed to severe or major impacts according to the selection criteria of the EUROWATERNET guidelines. For 2060 GW-bodies (78 % of all GW-bodies) size information is not available.

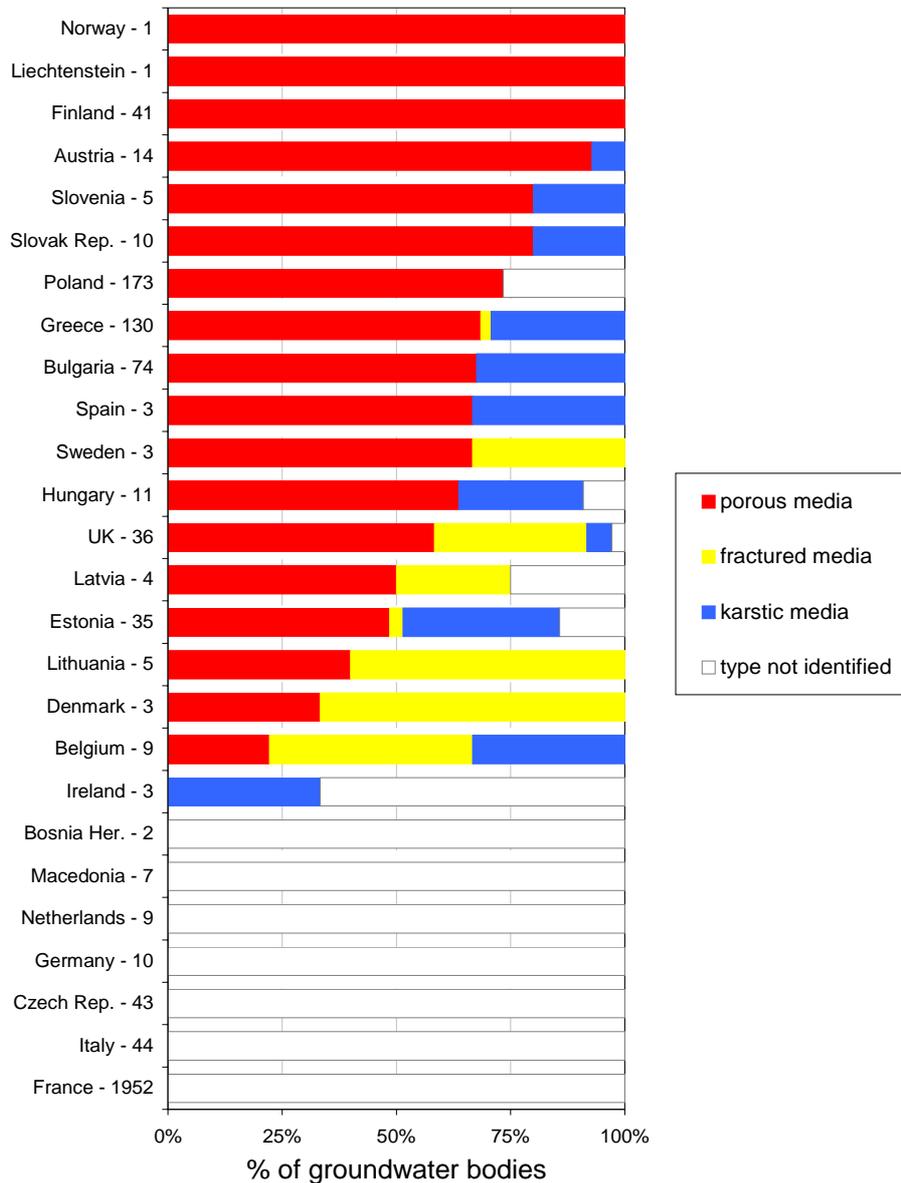
## Sub-indicator 9

### Type of aquifers of GW-bodies within EUROWATERNET-Groundwater

#### Key message

🕒 EUROWATERNET-Groundwater is based on a broad variety of groundwater bodies with regard to the distribution of types.

#### Type of aquifers of GW-bodies within EUROWATERNET-Groundwater



Note: The number of groundwater bodies is given after the country name.

Source: WATERBASE data collected through EUROWATERNET.

### Assessment of the sub-indicator

77 % of the GW-bodies (390) with provided information on type are GW-bodies in porous media. 17 % of the GW-bodies are in karstic media and in fractured media are 5 % of the GW-bodies. At about 81 % of all the GW-bodies information on the body type is not available.

### References

EEA (2000): Groundwater quality and quantity in Europe. Environmental assessment report No 3. European Environment Agency. Copenhagen.

EEA (2003): Europe's water: An indicator-based assessment. Topic report No 1/2003. Copenhagen. [http://reports.eea.eu.int/topic\\_report\\_2003\\_1/en](http://reports.eea.eu.int/topic_report_2003_1/en)

www.wfdgw.net (2001): The EU Water Framework Directive: Statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results.

[1] Implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Synthesis from year 2000 Member States reports. Report from the Commission. COM(2002) 407 final. Brussels. 2002.

[2] State of Environment in Latvia. 1996.  
<http://www.vkmc.vdc.lv/soe96/Soil/use%20of%20fertilisers>

[3] Trends in Fertiliser consumption. EEA data service.  
<http://dataservice.eea.eu.int/dataservice/viewdata/viewpvt.asp?id=184&i=1&res=3>

[4] German Environmental Report 2002.  
[http://www.bmu.de/english/download/files/umweltbericht\\_engl\\_2002.pdf](http://www.bmu.de/english/download/files/umweltbericht_engl_2002.pdf)

[5] State of Environment in Estonia. 2000. [http://nfp-ee.eionet.eu.int/SoE/index\\_en.htm](http://nfp-ee.eionet.eu.int/SoE/index_en.htm)

[6]: Indicator factsheet 02 - Numbers of livestock

[7]: Indicator factsheet 05 - Nitrogen balance in agricultural soils

### Data

#### Spreadsheet files

Main indicator: WEU1\_NO3\_main\_temporal.xls

Subindicators: WEU1\_NO3\_sub1\_regions.xls

WEU1\_NO3\_sub2\_status.xls

WEU1\_NO3\_sub3\_trends.xls

WEU1\_NO3\_sub4\_site-type.xls

WEU1\_NO3\_sub5\_body-size.xls

WEU1\_NO3\_sub6\_ammonium.xls

WEU1\_NO3\_sub7\_dissolvedoxygen.xls

WEU1\_EWN\_sub8\_body-size-all.xls

WEU1\_EWN\_sub9\_body-type-all.xls

### Meta data

#### Web presentation information

1. Abstract / description / teaser:

Describes nitrate status and development in groundwater bodies in Europe.

2. Policy issue / question:

Are nitrate concentrations in groundwater falling?

3. EEA dissemination themes:

Water

4. DPSIR:

S

Technical information

5. *Data source*: data collection for EUROWATERNET-Groundwater in 2002.
6. *Description of data*: for comparisons at the country level: % of GW-bodies or % of sampling sites. For comparison of time series: mg nitrate per litre
7. *Geographical coverage*: EEA
8. *Temporal coverage*: Most recent year: 1998–2001. Temporal development: 1989–2000. Trend /-reversal assessment: 1967–2001
9. *Methodology and frequency of data collection*: annual data collection through EUROWATERNET
10. *Methodology of data manipulation, including making 'early estimates'*: raw data have been aggregated on sampling site level (arithmetic mean), further aggregated on GW-body level (arithmetic mean) further aggregated on EEA level (arithmetic mean). Values below the limit of quantification were treated as 0. *Algorithm for trend/reversal assessment* can be found in: [www.wfdgw.net](http://www.wfdgw.net)

Quality information

11. *Strength and weakness (at data level)*: Strength: for some countries raw data as well as information on the sampling sites are available. Weakness: due to different sampling philosophy data might not be directly comparable. Large geographical data gaps.
12. *Reliability, accuracy, robustness, uncertainty (at data level)*: Data situation improved, temporal developments could have been performed due to increasing number of time series within a given time window. Several (very high) raw data might be corrected in future, but this will not change the interpretation of the overall situation.
13. Overall scoring (give 1 to 3 points: 1=no major problems, 3=major reservations):

Relevancy: 1

Accuracy: 2

Comparability over time: 2

Comparability over space: 2

**Further work required**

Countries should be motivated to provide data in order to close geographical data gaps. Countries should improve the completeness of the time series (filling gaps) and the completeness of the national coverage. Further validation and checking is the responsibility of the country and might lead to improved time series of nitrate in groundwater.