

Indicator Fact Sheet

(WEU2) Nutrients in rivers

(WEU5) BOD and ammonium in rivers

Author: Steve Nixon (WRc)

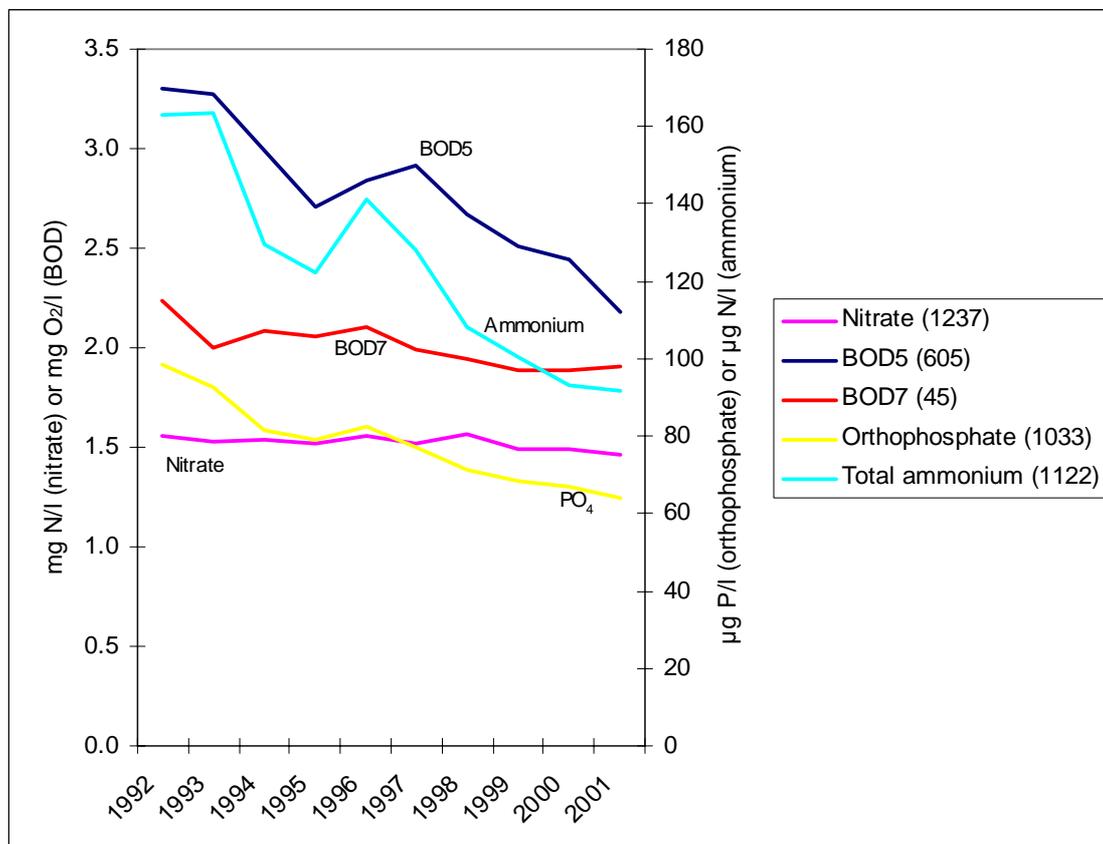
EEA project manager: Niels Thyssen

Indicator code / ID	WEU2, WEU5
Analysis made on (Assessment date)	7 May 2004
EEA contact / fact sheet responsible Name: Pavla Chyska Email: pavla.chyska@eea.eu.int	Fact sheet development contact point Name: Steve Nixon, WRc Email: nixon@wrcplc.co.uk

Key messages

- ☺ Concentrations of organic matter, ammonium and phosphate have generally decreased in European rivers during the 1990s reflecting the general improvement in wastewater treatment over this period.
- ☹ Concentrations of nitrate have generally remained steady in European rivers during the 1990s.

Figure 1 Concentrations of total ammonium, biochemical oxygen demand, nitrate and orthophosphate in European rivers between 1992 and 2001



Notes: Concentrations are median of the annual average concentrations per year. Total number of stations in brackets. Number of stations from each country per determinand shown below.

	BOD5	BOD7	Ammonium	Nitrate	Orthophosphate
AT	127		137	152	103

BG	44				
DE			108	111	87
DK	11		26	32	32
EE		45	41	45	45
FI			26	25	16
FR	297		294	341	315
HU	83		85	87	87
LT				56	56
LV			52	52	52
PL			91	92	88
SE			90	90	90
SK	9		9	9	
SL	21		21	21	21
UK	11		142	124	41

Source: Waterbase data collected through Eurowaternet

Results and assessment

Policy context:

There are a number of EU Directives aimed at reducing the loads and impacts of organic matter and nutrients. These include: the Nitrates Directive (91/676/EEC) aimed at reducing nitrate pollution from agricultural land; Urban Waste Water Treatment Directive (91/71/EEC) aimed at reducing pollution from sewage treatment works and from certain industries; Integrated Pollution Prevention and Control Directive (96/61/EEC) aimed at controlling and preventing pollution of water from industry; and the Water Framework Directive which requires the achievement of good ecological status or good ecological potential of rivers across the EU by 2015.

Environmental context:

Large inputs of nitrogen and phosphorus to water bodies can lead to eutrophication causing ecological changes that result in a loss of plant and animal species (reduction in ecological status), and have negative impacts on the use of water for human consumption and other purposes. In many catchments the main source of nitrogen pollution is run-off from agricultural land, though discharges from waste water treatment works can also be significant. For phosphorus, industry and households are often the most important sources. Control of these nutrient discharges is needed to reduce pollution levels in, and improve the ecological status of, water bodies. Natural concentrations of orthophosphate vary from catchment to catchment depending upon factors such as geology and soil type. Natural ranges are considered to be approximately 0 to 10 µg P/l. Concentrations of nitrate below 0.3 mg N/l are considered to be natural or background levels for most European rivers though for some rivers levels of up to 1mg N/l are reported. Concentrations of nitrate above 7.5 mg N/l are considered to be of relatively poor quality and exceed the guideline concentration for nitrate of 5.6 mg N/l as given in the Surface Water for Drinking Directive (75/440/EEC).

Ammonium concentrations are normally raised as a result of organic pollution, caused by discharges from waste water treatment plants, industrial effluents and agricultural runoff. It exerts a demand on oxygen in water as it is transformed to oxidised forms of nitrogen. In addition it is toxic to aquatic life at certain concentrations in relation to water temperature, salinity and pH. Background concentrations of ammonium are around 15 µg/l (as N).

BOD is a key indicator of the oxygenation status of water bodies. BOD is the oxygen demand brought about by organisms in water and sediment acting on oxidisable organic matter. In most European countries the BOD5 test is used where oxygen consumption is measured after 5 days incubation under controlled conditions. In other, mainly Northern Europe countries, the BOD7 test is used where samples are incubated for 7 days. High BOD is usually a result of organic pollution, caused by discharges from wastewater treatment plants, industrial effluents and agricultural run-off. High BOD has several effects on the aquatic environment including reducing river water chemical and biological quality, reducing biodiversity of aquatic communities and reducing the microbiological quality of waters. Background levels are difficult to quantify and are likely to be at or below the detection limit of the analytical method used i.e. between 1 and 2 mg O₂/l.

These indicators illustrate the current situation and trends regarding BOD, total ammonium, nitrate and orthophosphate in rivers.

Assessment:

The concentrations of orthophosphate, total ammonium and organic matter have been steadily decreasing in European rivers in general over the last 10 years. In EU countries this is because of the measures introduced by European legislation, in particular the Urban Waste Water

Treatment Directive which has increased levels of waste water treatment with, in many cases, increased tertiary treatment, often involving the removal of nutrients. There has also been an improvement in the level of waste water treatment in Accession countries though not to the same levels as in EU Member States. In addition, the transition recession in the economies of Accession countries may have played a part in the decreasing (phosphorus) trends because of the closure of potentially polluting industries and a decrease in agricultural production leading to less use of nitrogen and phosphorus fertilisers.

At the European level there is no clear trend (down or up) in concentrations of nitrate in rivers. This is because measures to reduce agricultural inputs of nitrate have not been implemented in a consistent way across EU countries and because the probable time lags between reduction of agricultural nitrogen inputs and soil surpluses, and resultant reductions in surface water concentrations of nitrate.

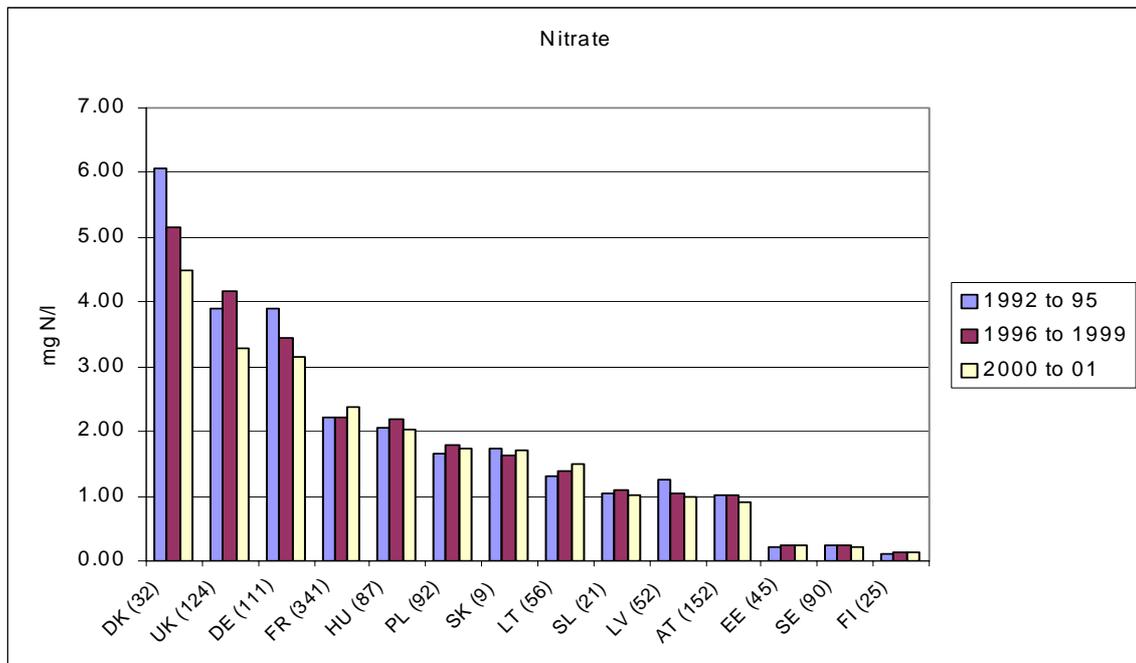
Sub-indicators

WEU2a: Trends in organic matter indicators and nutrients in rivers in some European countries

Key message

- ☺ There is evidence of nitrate concentrations decreasing in some rivers in some European countries over the last 10 years (Figure 2).
- ☺ Orthophosphate (Figure 3) and total ammonium (Figure 4) concentrations and biochemical oxygen demand (Figure 5) have decreased in rivers in many European countries over the last 10 years.
- ⊖ However, other than for the Nordic countries, concentrations of nitrate, orthophosphate and total ammonium are still above background levels.

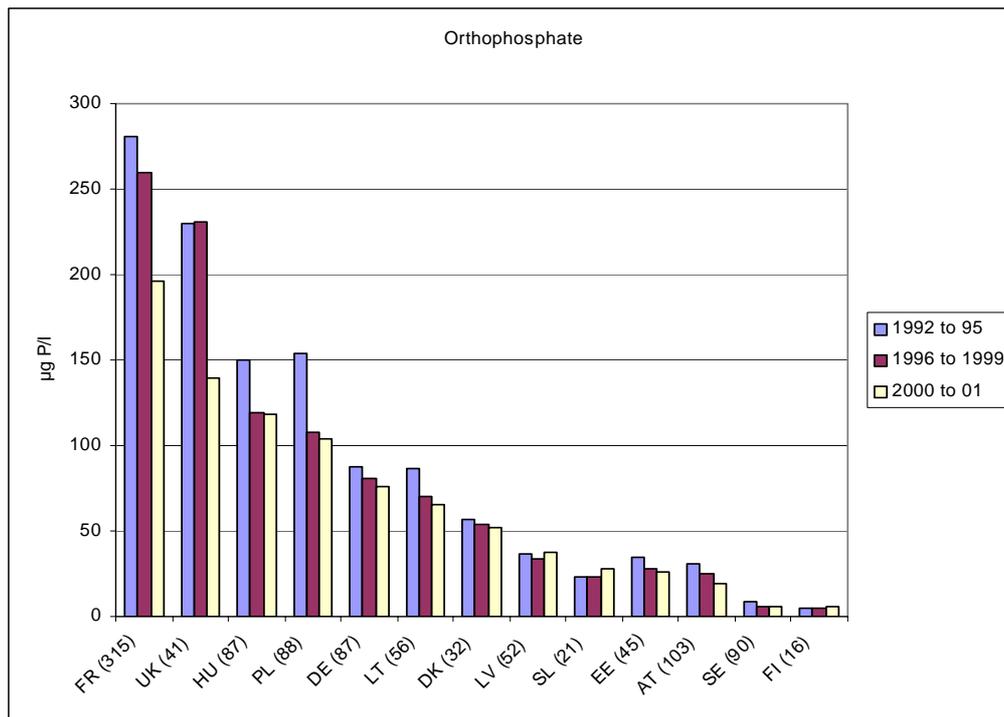
Figure 2 Trend in the median of the annual average nitrate concentrations (mg N/l) at river monitoring stations in some European countries between 1992 and 2001



Notes: Number of stations in brackets. Only stations with values for each year between 1992 and 2001 were used in the analysis. The median values for each year were averaged over the time periods indicated. All data are for nitrate other than for Denmark and Finland where total oxidised nitrogen (nitrate plus nitrite) has been used, and for the UK where a combination of nitrate and total oxidised nitrogen has been used.

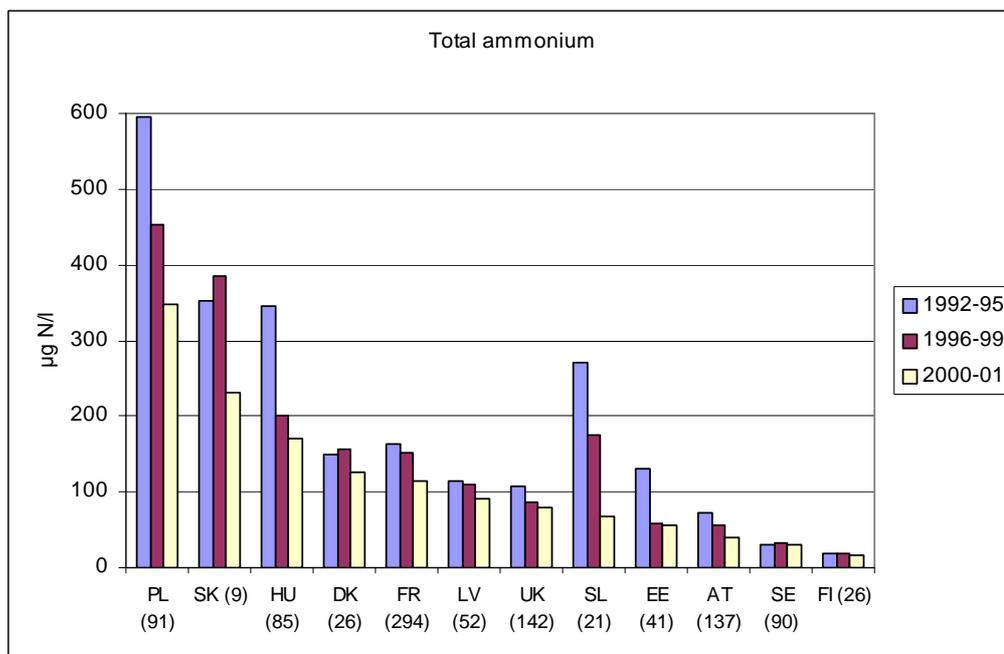
Source: Based on Eurowaternet data collection.

Figure 3 Trend in the median of the annual average orthophosphate concentrations ($\mu\text{g P/l}$) at river monitoring stations in some European countries between 1992 and 2001



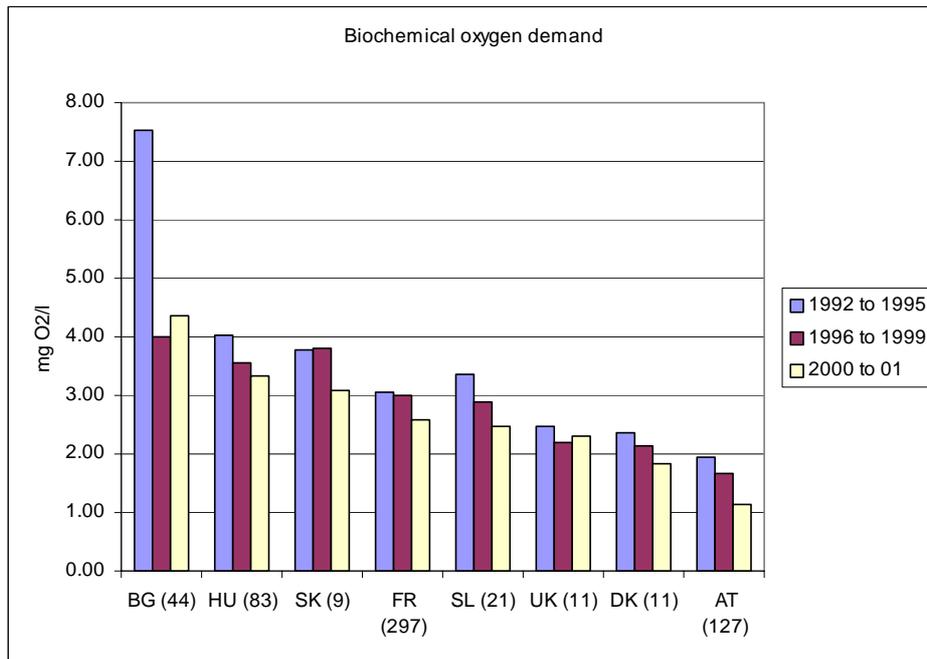
Notes: Number of stations in brackets. Only stations with values for each year between 1992 and 2001 were used in the analysis. The median values for each year were averaged over the time periods indicated.
Source: Based on Eurowaternet data collection.

Figure 4 Trend in the median of the annual average total ammonium concentrations ($\mu\text{g N/l}$) at river monitoring stations in some European countries between 1992 and 2001.



Notes: Number of stations in brackets. Only stations with values for each year between 1992 and 2001 were used in the analysis. The median values for each year were averaged over the time periods indicated.
Source: Based on Eurowaternet data collection.

Figure 5 Trend in the median of the annual average BOD₅ concentrations (mg O₂/l) at river monitoring stations in some European countries between 1992 and 2001



Notes: Number of stations in brackets. Only stations with values for each year between 1992 and 2001 were used in the analysis. The median values for each year were averaged over the time periods indicated.
Source: Based on Eurowaternet data collection.

Assessment for the sub-indicators

The general decreases in concentrations of orthophosphate, BOD and total ammonium in EU countries is the result of national and European measures to reduce emissions of these substances to water. European measures include those associated with the Urban Waste Water Treatment Directive and IPPC Directive. Observed decreases in EU candidate countries reflect a general but slow improvement in waste water treatment and also the closure of former polluting industries during the down turn in their economies whilst in transition to market-oriented economies.

The observed decrease in nitrate concentrations in some rivers of some EU countries is again the result of national and international measures to control nitrogen pollution, in particular, from agricultural sources. However the decreases in concentrations have been relatively slow because of poor implementation of the Nitrate Directive by EU countries and because of the sometimes long delays between measures being applied and concentrations decreasing. The latter could be due, for example, to large nitrogen surpluses in agricultural soil which potentially may take years to decrease. Any decreases in EU candidate countries are likely to be due to the decrease in agricultural productivity during the economic transition period, for example the decrease in use of nitrogenous fertilisers.

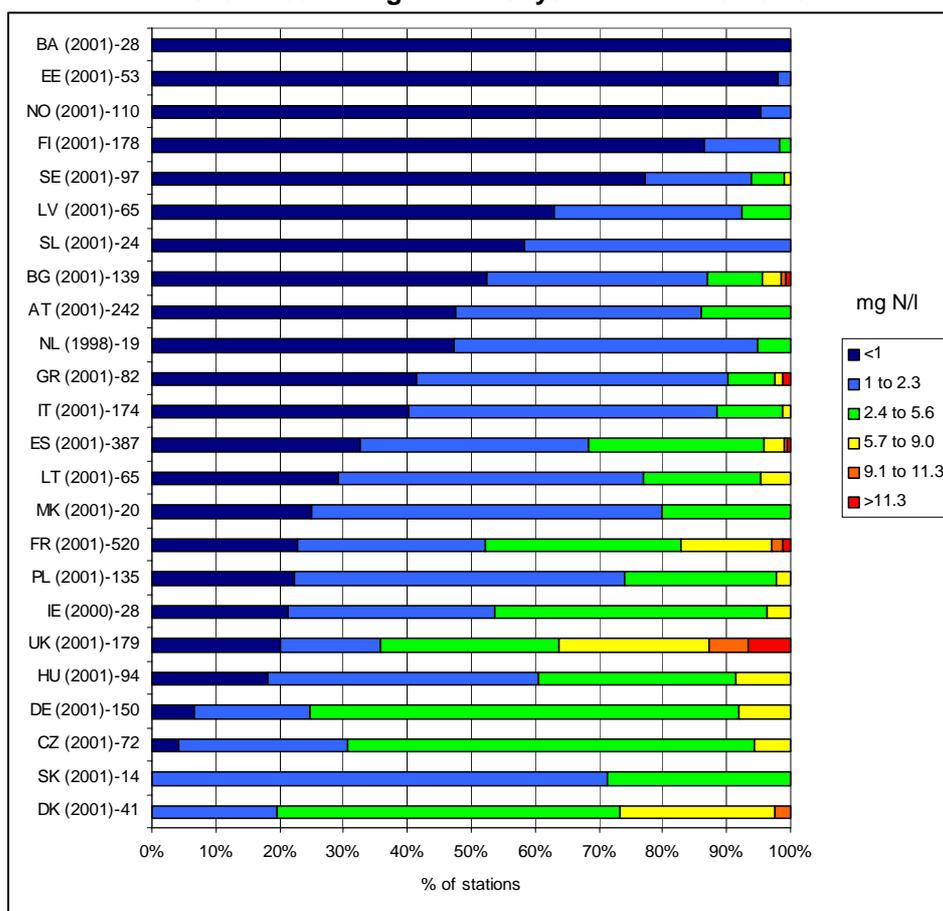
Sub-indicator

WEU2b: Concentration distributions of organic matter and nutrients in the rivers of European countries

Key message

- The concentrations of nitrate, orthophosphate, total ammonium and organic matter (BOD) in rivers in the different European countries reflect the relative importance and intensity of the driving forces affecting water quality. Those countries with low intensity driving forces perhaps coupled with effective measures to reduce nutrient and organic matter emissions (pressures) (particularly the Nordic countries) generally have relatively low concentrations of these determinands. In contrast those countries with high intensity driving forces, perhaps coupled with ineffective measures to reduce emissions have relatively high concentrations (for example some EU candidate countries).

Figure 6 Concentration distributions of nitrate (mg N/l) in rivers in European countries during the latest year with available data

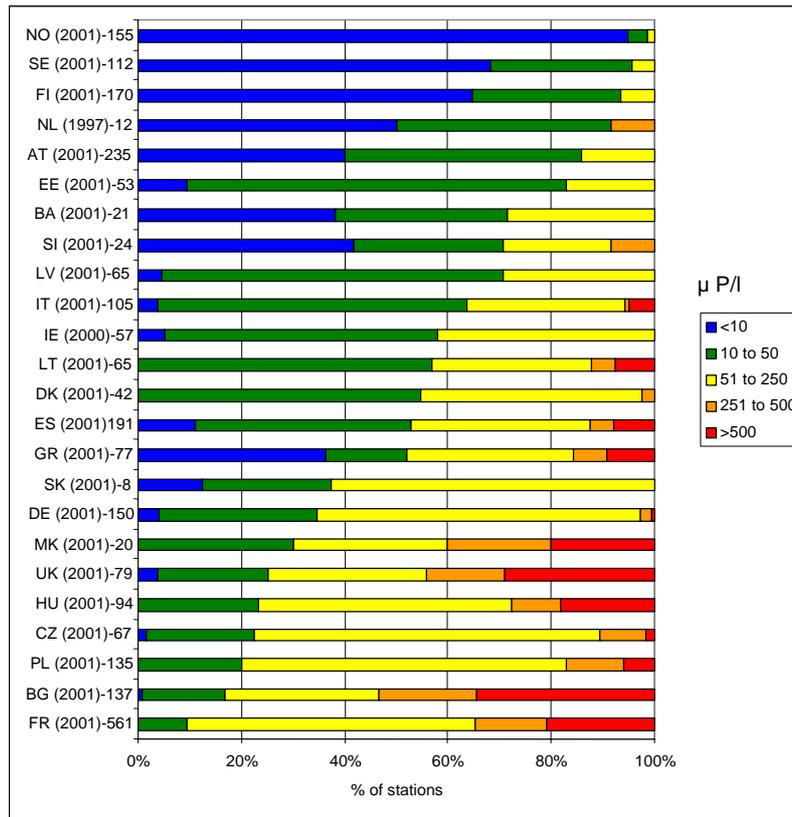


Notes: Latest year in brackets, followed by number of river stations (all types of Eurowaternet station). Distribution of station's annual average concentrations:

AT = Austria, BA = Bosnia and Herzegovina, BG = Bulgaria, CZ = Czech Rep., DE = Germany, DK = Denmark, EE = Estonia, ES = Spain, FI = Finland, FR = France, GR = Greece, HU = Hungary, IE = Ireland, IT = Italy, LT = Lithuania, LV = Latvia, MK = Former Yugoslav Rep. of Macedonia, NL = Netherlands, NO = Norway, PL = Poland, SE = Sweden, SK = Slovak Rep., SL = Slovenia, UK = United Kingdom

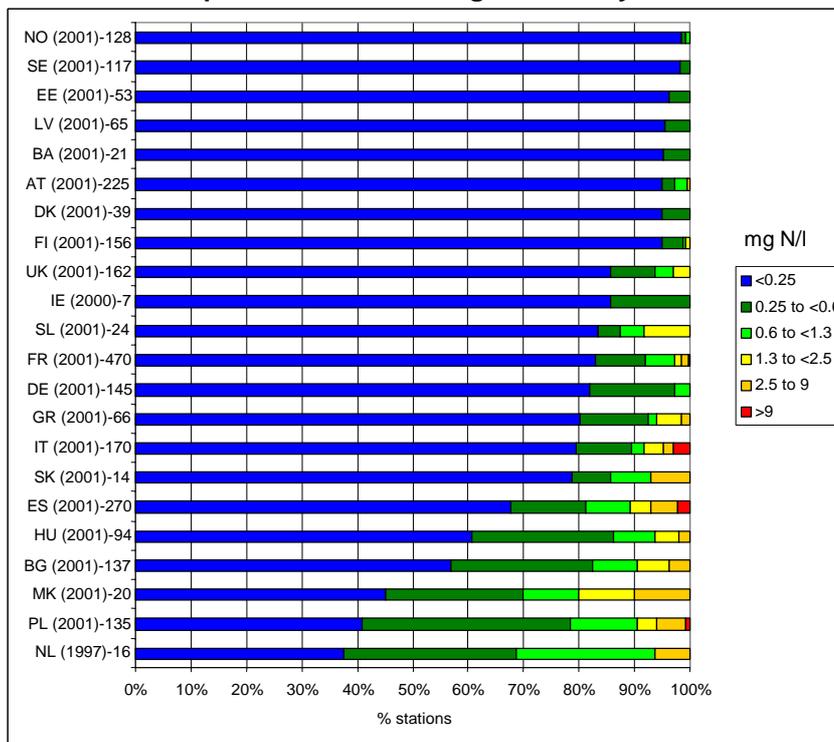
Source: Eurowaternet and Waterbase

Figure 7 Concentration distributions of orthophosphate ($\mu\text{g P/l}$) in rivers in European countries during the latest year with available data



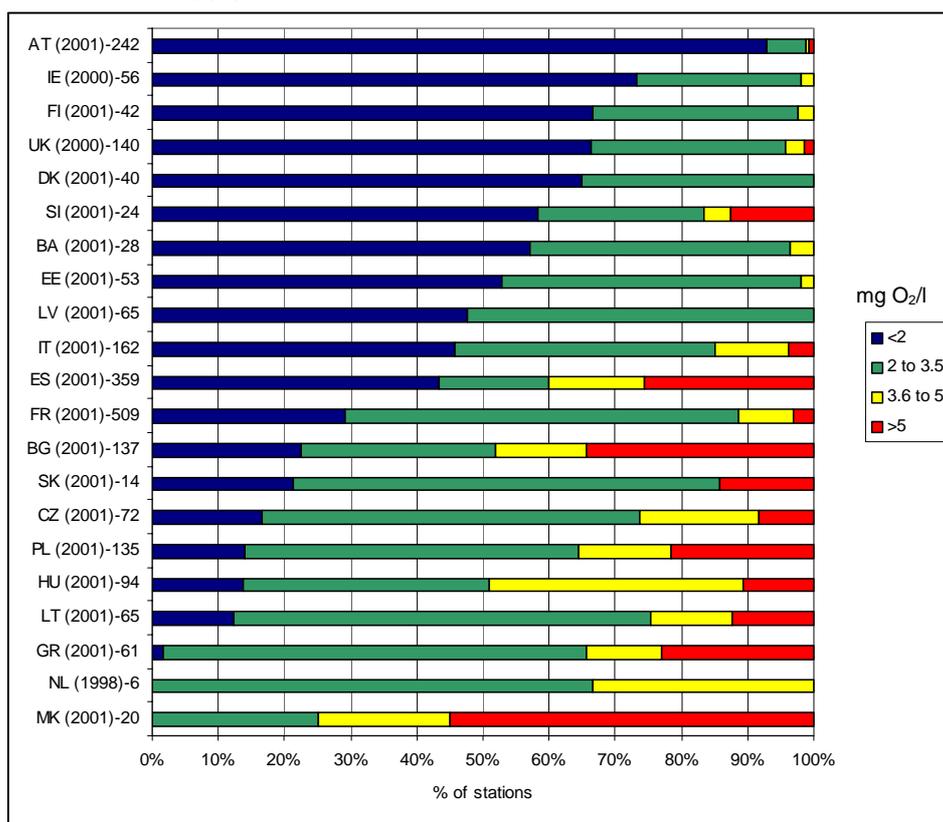
Notes: Latest year in brackets, followed by number of river stations. Distribution of stations' annual average concentrations. For country codes see Figure 6.
Source: Eurowaternet and Waterbase

Figure 8 Concentration distributions of total ammonium (mg N/l) in rivers in European countries during the latest year with available data



Notes: Latest year in brackets, followed by number of river stations. Distribution of stations' annual average concentrations. For country codes see Figure 6.
Source: Eurowaternet and Waterbase

Figure 9 Concentration distributions of biochemical oxygen demand (BOD) (mg O₂/l) in rivers in European countries during the latest year with available data



Notes: Latest year in brackets, followed by number of river stations. Distribution of stations' annual average concentrations. For country codes see Figure 6.
Source: Eurowaternet and Waterbase

Assessment for the sub-indicators

In terms of nitrate, 14 of the 24 countries with available information had a number of stations where the Drinking Water Directive guide concentration for nitrate of 5.6 mg N/l (25 mg NO₃/l) was exceeded, and five of these countries had stations where the maximum allowable concentration of 11.3 mg N/l (50 mg NO₃/l) was also exceeded. Countries with the greatest agricultural land use and highest population densities (such as Denmark, Germany, Hungary and the UK, generally had higher nitrate concentrations than those with the lowest (such as Estonia, Norway, Finland, and Sweden reflecting the impact of emissions of nitrate from agriculture and waste water treatment works, respectively.

Those countries with high proportions of nutrient removal in their sewage treatment works (such as Sweden, Finland and the Netherlands) have relatively low orthophosphate concentrations whereas those countries with relatively low nutrient removal, high population densities and high phosphorus fertiliser usage (such as France, Italy and UK) tend to have relatively high orthophosphate concentrations.

Total ammonium concentrations are lowest in those countries with high levels of sewage treatment, low population densities and low agricultural land use (such as Norway, Sweden, Estonia, Latvia and Finland). The Netherlands tends to have the highest total ammonium concentrations reflecting the high density of livestock that is a potential source of ammonium pollution. Denmark also has high livestock densities but lower (than expected) concentrations of total ammonium. This may reflect different livestock husbandry measures in each country, one less polluting than the other.

In terms of BOD (organic matter), those countries with a relatively high proportion of at least secondary treatment tend to have the lowest concentrations whilst those with the least have the highest concentrations. The exception appears to be the Netherlands (however, note that only six stations were provided) that has very high levels of sewage treatment implying that the organic matter is arising from sources other than sewage treatment works.

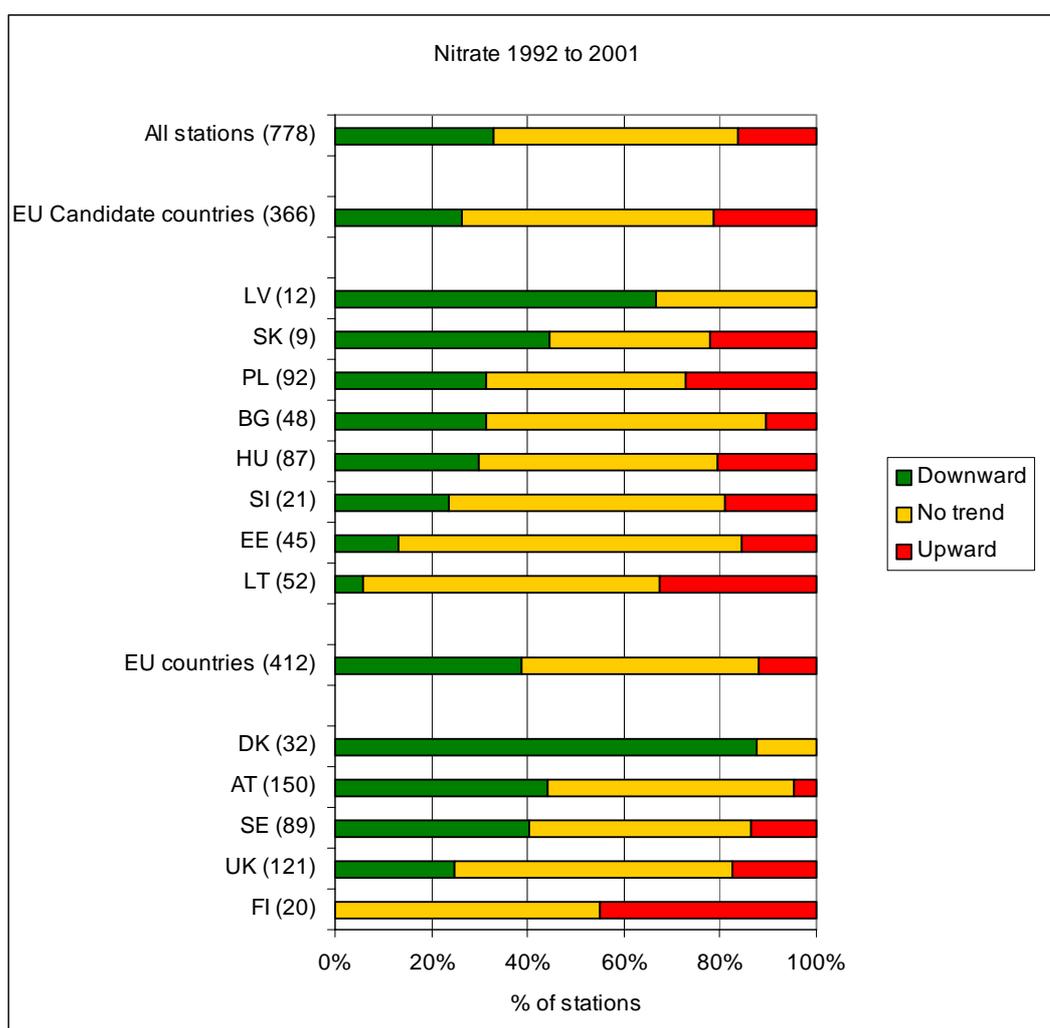
Sub-indicator

WEU2c: Statistically significant trends in concentrations of nutrients at river monitoring stations

Key message

- ☺ Around 30% of monitoring stations on Europe's rivers showed a decreasing trend of nitrate concentrations between 1992 and 2001 reflecting the success of legislative measures to reduce nitrate pollution.
- ☹ However, nearly 20% of river stations also showed increasing trends of nitrate over the same period, reflecting that emissions of nitrate in the catchments of these rivers may have not yet been reduced or indicating that the effects of reducing emissions have not yet become evident because, for example, high nitrogen surpluses in agricultural soils.

Figure 10 Trends in nitrate concentration at monitoring stations between 1992 and 2001



Notes: The number of stations per country and country grouping is shown in brackets. The statistical significance ($P < 0.05$) of trends has been calculated using Sen's test. Each station assessed had 10 years of annually averaged data with an estimate of the standard deviation.

Source Eurowaternet and Waterbase

Assessment for the sub-indicator

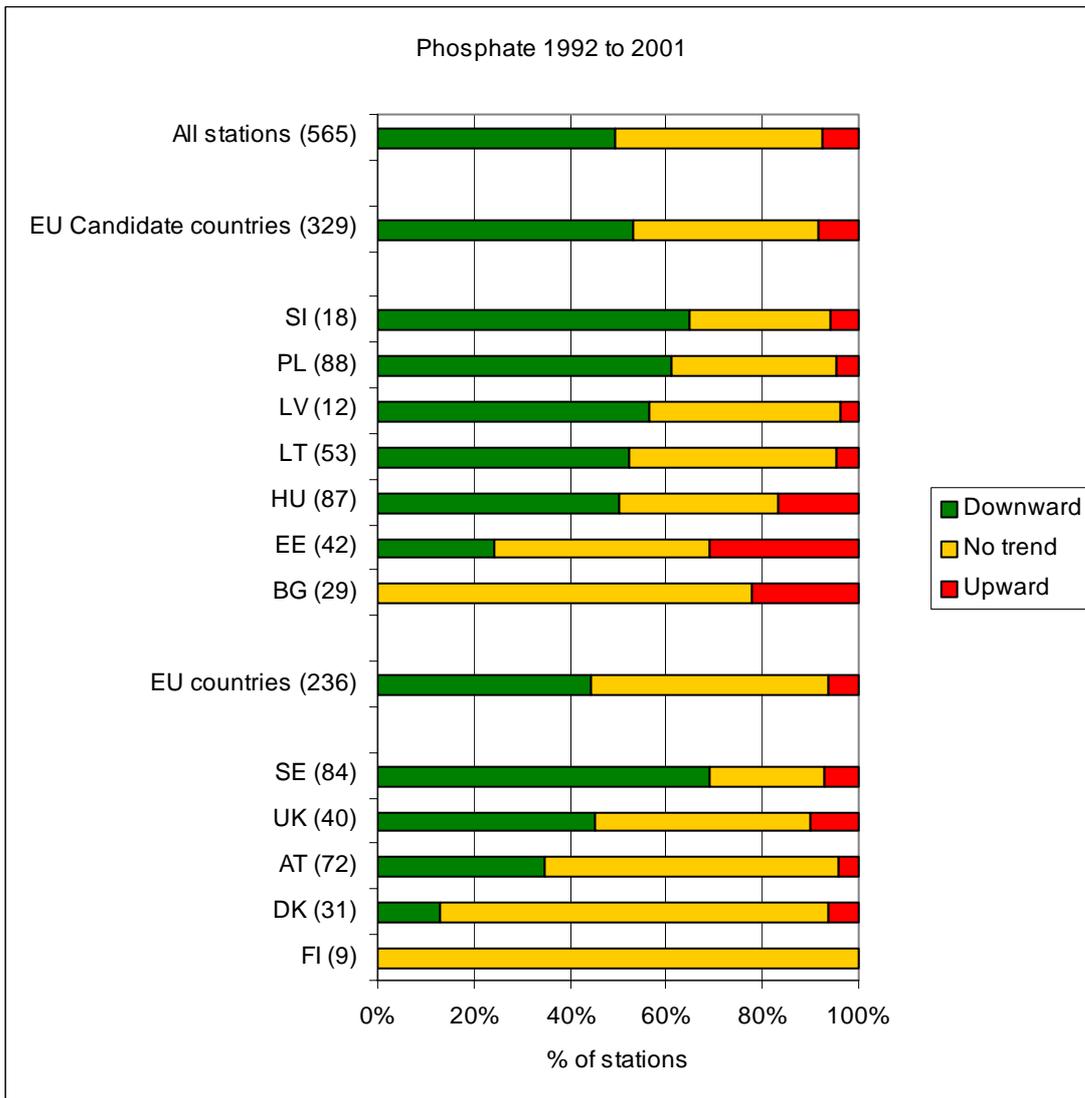
Figure 10 indicates that there are significant decreases in nitrate concentrations at some river stations in some European countries. In the EU countries assessed, Denmark had the highest proportion of stations with decreasing trends indicating that national and EU measures introduced to reduce nitrate pollution, such as those in the Nitrates Directive, are having some

effect. Finland (with other Nordic countries) generally has the lowest nitrate concentrations in its rivers. However, about 40% of Finnish stations showed an increasing concentration between 1992 to 2001, perhaps indicating increasing pressures from agriculture and other sectors emitting nitrate. Also the varying hydrological conditions may at least partly explain the upward trends. The other EU countries Austria, Sweden and UK had different proportions of river stations with decreasing, stationary and increasing trends. In the EU candidate countries, Latvia had the highest proportion of river stations with decreasing nitrate concentrations and no stations with increasing trends. The other candidate countries had varying proportions of stations with decreasing, no and increasing trends. The decreasing trends are probably because of the decrease in agricultural productivity and activity in these countries during the transition of their economies to become more market orientated. This has led to, for example, decreases in nitrogenous fertiliser use and in numbers of livestock (and hence manure production), both potential sources of nitrate pollution.

Key message

- ☺ Around 50% of monitoring stations on Europe’s rivers showed a decreasing trend of orthophosphate concentrations between 1992 and 2001 reflecting the success of legislative measures to reduce emissions of phosphorus such as those required by the Urban Waste Water Treatment Directive.
- ☹ However, 10% of river stations also showed increasing trends of orthophosphate over the same period, reflecting that emissions of phosphate in the catchments of these rivers may have not yet been reduced or indicating that there might be in some catchments increasing phosphorus surpluses in agricultural soils.

Figure 11 Trends in concentrations of phosphate at monitoring stations between 1992 and 2001



Notes: The number of river stations per country and country grouping is shown in brackets. The statistical significance ($P < 0.05$) of trends has been calculated using Sen's test. Each station assessed had 10 years of annually averaged data with an estimate of the standard deviation.

Source: Eurowaternet and Waterbase

Assessment for the sub-indicator

All EU countries assessed (except Finland) had a higher proportion of stations with decreasing phosphate concentration than those with increasing trends. Finland has (with other Nordic countries) the lowest concentrations of phosphate in its rivers reflecting its generally low population density and the high level of nutrient removal undertaken at sewage treatment works. Finland's river stations showed no trend in phosphate concentrations. As already stated, phosphate concentrations in Finland are low and they are often close to the detection limit. Because the concentrations are so low they cannot easily be decreased further. It is therefore unlikely that clear trends would be detected. In addition, the number of available stations in Finland for this assessment was low (9). Consequently general conclusions concerning the whole country should be drawn with caution.

The increasing trends might be because of ineffective control of phosphorus in some river catchments, particularly those with relatively small (in terms of load) sources of phosphorus that might fall outside of legislative requirements. Dishwasher detergents containing phosphorus are also becoming increasingly important as dishwashers are increasingly used in more affluent societies. There are also cases where agricultural sources of phosphorus are becoming more important in catchments as point sources are progressively reduced. Phosphorus surpluses may also be increasing in some agricultural soils.

All EU candidate countries except Bulgaria had some river stations with decreasing phosphate concentrations. Increasing trends were also found at a smaller proportion (than decreasing trends) of river stations in all candidate countries. The decreasing trends reflect a general improvement of sewage treatment in these countries (though they have not yet fully implemented the Urban Waste Water Treatment Directive¹) and/or the closure of polluting industries that has occurred during the restructuring of their economies as part of the process of transition into the EU.

Data

Spreadsheet file: WEU2_WEU5_NutrientsRivers_2.xls

Meta data

Web presentation information

1. Abstract / description / teaser:

Shows the concentrations of nutrients (orthophosphate, nitrate, total ammonium and organic matter) in European rivers.

2. Policy issue / question:

Are nutrient concentrations in surface waters decreasing?

3. EEA dissemination themes:

Water

4. DPSIR:

S

Technical information

5. Data source: Waterbase - EEA-ETC/WTR database containing Eurowaternet data.

6. Description of data: The source data are river station annual averages of total oxidised nitrogen, nitrate, orthophosphate, total ammonium and biochemical oxygen demand (5 day or 7 day measurement). Data are from 'representative' monitoring stations, i.e. those which

¹ Ten candidate countries (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic, and Slovenia) joined the EU on 1 May 2004, and have agreed with the European Commission a timetable for the full implementation of EU Directives.

reflect the majority of rivers in a region/area with human activities in the catchment consistent with the region's/area's activities.

7. Geographical coverage: EEA countries
8. Temporal coverage: Data are available from 1975-2001. Data from only 1992 to 2001 are used for this assessment. This period had the most consistent dataset in terms of years, numbers of stations and countries covered.
9. Methodology and frequency of data collection: Through data exchange with NFPs collected annually.
10. Methodology of data manipulation: Data are reported as annual averages (plus other statistics) for each station included in Eurowaternet. The data between stations are highly skewed and hence median concentrations of the stations' annual averages are used to summarise the country-aggregated, station-size and catchment type aggregated data. In contrast for the distributions of concentrations for the most recent year per country, the reported station annual average concentration is used. This is because many countries only reported station annual average concentration and not annual median concentrations.

Qualitative information

11. Strength and weakness (at data level): A very consistent and comparable time series has been obtained. This covers more stations and countries across Europe than has been previously available. For the first time comparable information is also available on the smaller rivers of Europe. At the moment the most detailed information is from relatively few western countries, and there are less time series data for the southern countries.
12. Reliability, accuracy, robustness, uncertainty (at data level): The data are provided by official national data sources and have largely been validated. The Eurowaternet stations are designed to give a representative overview of the status in each country. There is a large amount of data variability within each strata and within each year. This could perhaps be reduced by a more powerful and thorough statistical assessment.

13. Overall scoring

Relevancy: 1

Accuracy: 1

Comparability over time: 1

Comparability over space: 1

Further work required

This indicator will be improved as more countries implement Eurowaternet. There are gaps in river characteristic information from some countries. This does not enable stratification by river size, and thus limits the current dataset for size-stratification. Also many countries did not report all the requested summary statistics such as the median. A bigger gap in the information is in terms of catchment pressures. Some countries have used Corine land cover data to provide proxy indicators of pressures. It is expected that this aspect will improve significantly during the next year as new updated Corine data will be available, and as work is undertaken by the ETC/WTR and ETC Terrestrial Environment to fill in the gaps in the pressure indicators. More times series data would improve the dataset particular from Southern countries.