Nutrients in freshwater in Europe (8th EAP)

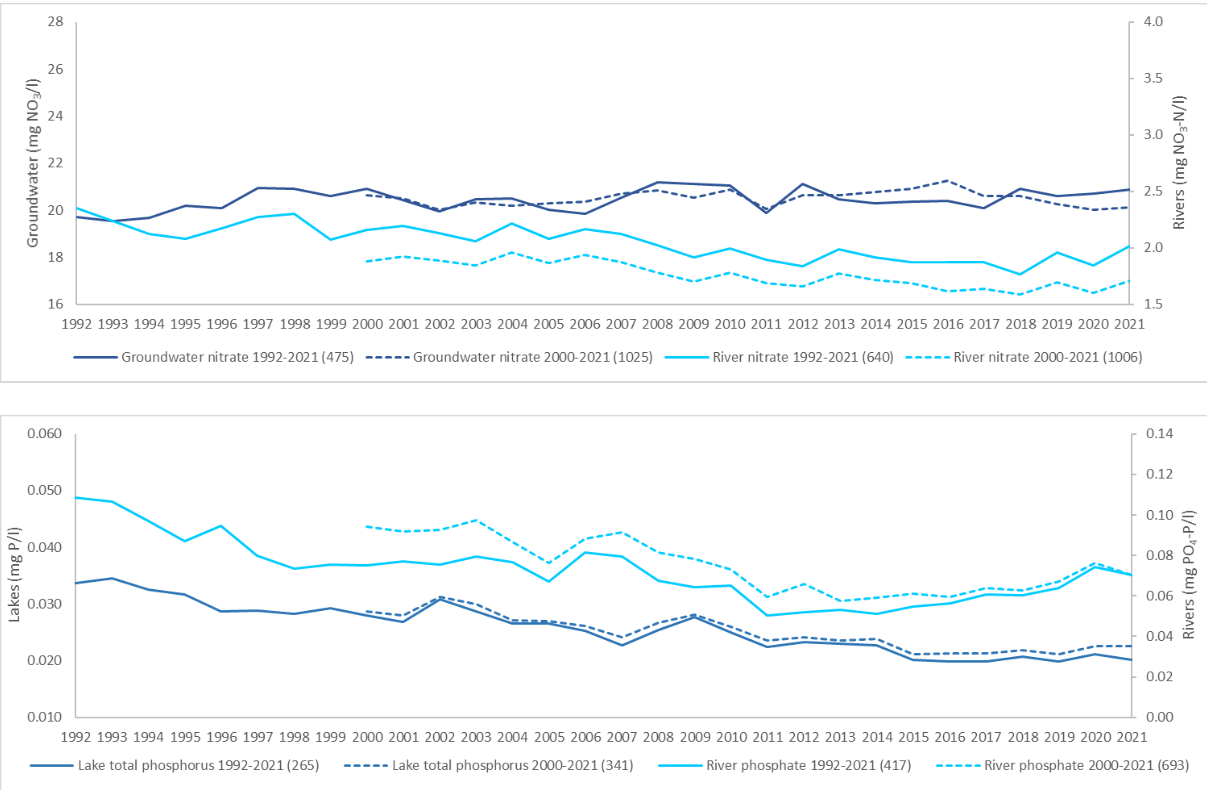
Last update [Publish Date] – next update [Publish Date]

EU level

Summary

Nutrient conditions in European surface waters have improved in recent decades. The average nitrate and phosphate concentrations in rivers and total phosphorus concentration in lakes have decreased. The decrease in nutrient concentrations is likely related to improvements in wastewater treatment, the reduction of phosphorus in detergents and measures reducing agricultural inputs. There is a tendency for concentrations to level off in recent years, especially for rivers. There has been no overall decrease in the nitrate concentration in groundwater.

Figure 1. Nutrients in European water bodies



Notes:

Additional information

The geographical coverage is the 38 EEA member countries, but only complete time series are included in the analysis. The selected time series are aggregated to European level by averaging across all sites for each year.

Two time series are shown – a longer time series representing fewer water bodies and a shorter time series representing more water bodies.

Upper chart:

Nitrate in groundwater: The number of groundwater bodies included per country is given in parenthesis:

- **1992-2021:** Europe (475), Austria (14), Belgium (24), Bulgaria (25), Denmark (1), Estonia (16), Finland** (7), France (260), Germany (67), Ireland (49), Portugal (2), Slovakia (4), Slovenia (5), Spain (1).

- **2000-2021:** Europe (1025), Austria (14), Belgium (37), Bulgaria (40), Cyprus (6), Czechia (64), Denmark (4), Estonia (18), Finland** (8), France (452), Germany (176), Ireland (66), Italy (10), Latvia (11), Malta (2), Portugal (10), Serbia (21), Slovakia (16), Slovenia (6), Spain (25), Switzerland (37).

Nitrate in rivers: The number of river monitoring sites included per country is given in parenthesis:

- **1992-2021:** Europe (640), Albania (3), Belgium (26), Czechia (22), Denmark* (36), Estonia (34), Finland** (60), France** (3), Germany (119), Ireland** (4), Latvia (13), Lithuania (22), Poland (13), Slovakia (8), Slovenia (7), Spain** (154), Sweden* (110), Switzerland (6).

- **2000-2021:** Europe (1006), Albania (7), Belgium (34), Cyprus (13), Czechia (22), Denmark* (37), Estonia (36), Finland** (69), France** (3), Germany (122), Iceland (1), Ireland** (50), Italy (25), Latvia (16), Lithuania (22), North Macedonia (17), Poland (16), Romania (89), Serbia (33), Slovakia (8), Slovenia (8), Spain** (250), Sweden* (112), Switzerland (16).

(* = all data total oxidised nitrogen, ** = some data total oxidised nitrogen)"

Lower chart:

Phosphate in rivers: The number of river monitoring sites included per country is given in parenthesis:

- **1992-2021:** Europe (417), Belgium (24), Bulgaria (32), Czechia (10), Denmark (38), Estonia (35), Finland (59), Ireland (4), Latvia (13), Lithuania (22), Norway (18), Slovakia (6), Slovenia (7), Spain (33), Sweden (110), Switzerland (6).

- **2000-2021:** Europe (417), Albania (3), Belgium (28), Bulgaria (53), Croatia (23), Czechia (10), Denmark (39), Estonia (37), Finland (66), Iceland (1), Ireland (33), Italy (18), Latvia (16), Lithuania (22), Norway (18), Romania (88), Serbia (33), Slovakia (6), Slovenia (8), Spain (46), Sweden (112), Switzerland (16).

Total phosphorus in lakes: The number of lake monitoring sites included per country is given in parenthesis:

- **1992-2021:** Europe (265), Austria (5), Denmark (5), Estonia (7), Finland (143), Germany (3), Lithuania (2), Netherlands (6), Norway (2), Slovenia (2), Sweden (90).

- **2000-2021:** Europe (341), Austria (27), Belgium (1), Bulgaria (1), Croatia (3), Denmark (5), Estonia (8), Finland (167), France (1), Germany (6), Lithuania (3), Netherlands (6), Norway (3), Poland (9), Serbia (3), Slovenia (3), Sweden (95).

Aggregate level assessment

Nitrate in groundwater

The average nitrate concentration in European groundwater is fluctuating around the same level and there is no clear trend (Figure 1). The shorter, but more representative time series starting in 2000 follows the longer one closely. Agricultural activities, such as over-use of fertilizer, is the main driver for nitrate in groundwater.

Nitrate in rivers

The average nitrate concentration in European rivers decreased steadily over the period 1992-2009 but has levelled off since then. The shorter time series is parallel to the longer series, but the concentration level is lower. Agriculture remains the main contributor to nitrogen pollution, but the EU Nitrates Directive and national measures have contributed to lower concentrations. However, the apparent stabilisation in recent years calls for further measures.

Phosphate in rivers

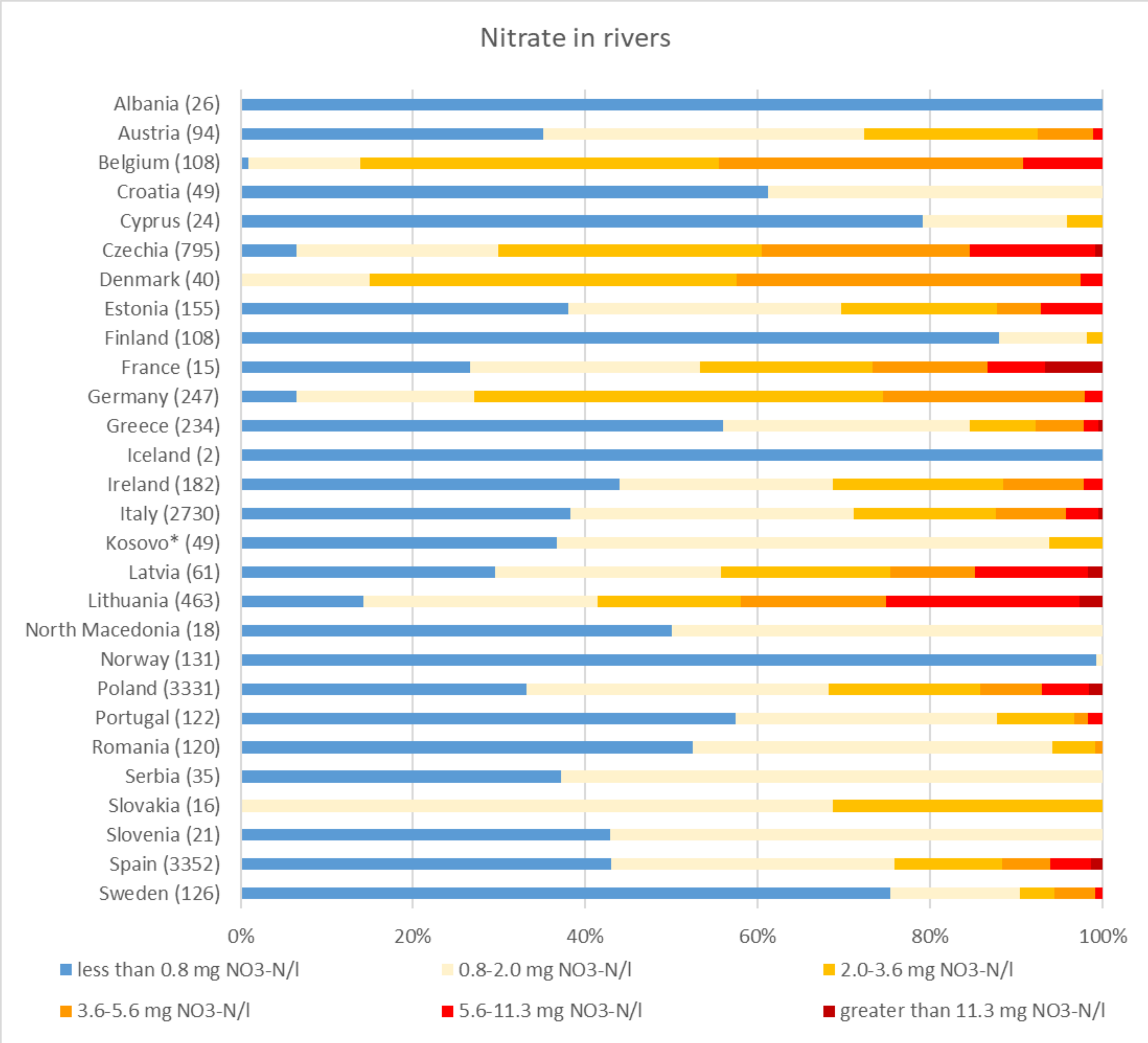
The average phosphate concentration in European rivers more than halved over the period 1992-2011. The marked decline is also evident for the shorter time series, but the average concentration is somewhat higher. From 2011 onwards the concentration tends to level off and in the last five years even increase, indicating a need for further measures. The overall decrease in river phosphate can be related to measures introduced by national and European legislation, e.g. the Urban Waste Water Treatment Directive. Also, the change to phosphate-free detergents has contributed to lower phosphate concentrations.

Total phosphorus in lakes

There has been a gradual reduction in average total phosphorus concentration in European lakes since 1992, but the concentration levels off from 2015. The concentration level is somewhat higher for the shorter, more representative time series. As the treatment of urban wastewater has improved, phosphorus from detergents has been reduced, and many wastewater outlets have been diverted away from lakes, so phosphorus from point sources has become less significant. However, diffuse runoff from agricultural land continues to be a major phosphorus source in European lakes. Moreover, phosphorus stored in sediment can keep lake concentrations high despite a reduction in inputs.

Country level

Figure 2. Nitrate in rivers in European countries



Notes:

Kosovo* refers to Kosovo under UNSC Resolution 1244/99.

The current concentration per river site is calculated as the average of available annual mean concentrations for the years 2019-2021. Concentrations are in mg nitrate-nitrogen per litre (mg NO_3-N/l).

The river sites are assigned to different concentration classes to visualise the distribution of data in the dataset. 11.3 mg NO_3-N/l corresponds to the maximum allowable concentration for nitrate of 50 mg/l in the Drinking Water Directive (2020/2184) and the Groundwater Directive (2006/118). The number of river sites per country is given in parenthesis.

Disaggregate level assessment

Rivers that drain land with intense agriculture or a high population density generally have the highest nitrate concentrations. In the period 2019-2021 (Figure 2), Lithuania had the largest proportion of river sites with average nitrate concentrations exceeding 5.6mg NO_3-N/l (25%). Moreover, Belgium, Czechia, and Denmark had a high proportion (more than 35%) of sites with concentrations exceeding 3.6mg NO_3-N/l.

There has been a significant decrease in river nitrate concentrations at 47% of the monitoring sites since 1992, and an increase at 12% of the sites. Czechia, Denmark, Germany and Slovakia had the highest proportion of significantly decreasing trends (82-100%). Spain and Switzerland had similar proportions of significantly increasing and decreasing trends, while Estonia and Lithuania had the highest proportion of significantly increasing trends (44% and 45%, respectively). An overall decline, although slowing in recent years, is observed for Belgium, Czechia, Denmark, Germany, Serbia and Sweden, contributing to the pattern seen in the European time series (Figure 1).

Definition

This indicator shows concentrations of phosphate and nitrate in rivers, total phosphorus in lakes and nitrate in groundwater bodies. The indicator can be used to illustrate geographical variations in current nutrient concentrations and temporal trends. Large inputs of nitrogen and phosphorus to water bodies from waste water and agricultural areas can lead to eutrophication. This causes ecological changes that can result in a loss of aquatic biodiversity (reduction in ecological status) and can have negative impacts on the use of water for human consumption and recreation.

Methodology

Annual mean concentrations are used as a basis in the indicator analyses. The aggregation to annual mean concentrations is done by the EEA, unless the country has reported aggregated data only.

Automatic quality control procedures are applied both to the disaggregated and aggregated data, and data failing certain tests are excluded from further analysis. In addition, a semi-manual procedure is applied, focusing on suspicious values having a major impact on the country time series and on the most recently reported data. This comprises e.g.:

• outliers;

• consecutive values deviating strongly from the rest of the time series;

• whole time series deviating strongly in level compared to other time series for that country and determinand;

• where values for a specific year are consistently far higher or lower than the remaining values for that country and determinand.

Such values are removed from the analysis and checked with the country.

For time series analyses, only complete series after inter/extrapolation are used. This is to ensure that the aggregated time series are consistent, i.e. including the same sites throughout. Inter/extrapolation of gaps up to 3 years are allowed, to increase the number of available time series. At the beginning or end of the data series missing values are replaced by the first or last value of the original data series, respectively. In the middle of the data series, missing values are linearly interpolated. The selected time series are aggregated to country and European level by averaging across all sites for each year.

Trends are analysed with the Mann-Kendall method in the free software R , using the wql package. This is a non-parametric test suggested by Mann (1945) and has been extensively used for environmental time series . Mann-Kendall is a test for a monotonic trend in a time series y(x), which in this analysis is nutrient concentration (y) as a function of year (x). The size of the change is estimated by calculating the Sen slope . Absolute and relative Sen slopes are summarized across Europe and countries by averaging. For the trend analysis the same time series as for the time series analysis are used, but without gap filling.

For analysis of the present state, average concentrations are calculated across the last 3 years with data. In this way data from far more groundwater bodies and lake and river sites can be used than in the time series analysis. The 3-year average is used to remove some inter-annual variability. Also, since data are not available for all sites each year, selecting data from 3 years gives more sites. The sites are assigned to different concentration classes and summarised per country (percentage of sites per concentration class). The purpose of the analysis is to compare the distribution of concentrations among countries. The class boundaries are thus mainly selected to represent the range of concentrations and are neither linked to targets or goals of specific policies nor to national based thresholds. The only exception is the threshold of 50 mg NO_3/l (11.3 mg NO_3-N/l), which is related to the maximum allowable concentration for nitrate in the Drinking Water Directive (2020/2184) the Groundwater Directive (2006/118).

Policy/environmental relevance

Freshwater quality with respect to eutrophication and nutrient concentration is an objective of several directives and other policies: the Nitrates Directive (91/676/EEC); the Urban Waste Water Treatment Directive (91/271/EEC); the Industrial Emissions Directive (2010/75/EU); the Convention on Long-range Transboundary Air Pollution and the National Emission Ceilings Directive (2016/2284/EU); and the Water Framework Directive (2000/60/EC). The Drinking Water Directive (2020/2184) and the Groundwater Directive (2006/118) sets the maximum allowable concentration for nitrate of 50 mg NO_3/l.

Reducing nutrient pollution from agriculture is an aspect of the European Green Deal, the 'Farm to Fork' Strategy, the Biodiversity Strategy and the Common Agricultural Policy.

Accuracy and uncertainties

Methodology uncertainty

Nutrient conditions vary throughout the year depending on, for example, season and flow conditions. Hence, the annual average concentrations should ideally be based on samples collected throughout the year. Using annual averages representing only part of the year introduces some uncertainty, but it also makes it possible to include more sites, which reduces the uncertainty in spatial coverage. Moreover, the majority of the annual averages represent the whole year.

Nitrate concentrations in groundwater originate mainly from anthropogenic activities as a result of agricultural land use. Concentrations in water are the effect of a multidimensional and time-related process, which varies from groundwater body to groundwater body and is less quantified. To properly evaluate the nitrate concentration in groundwater and its development, closely-related parameters such as ammonium and dissolved oxygen should be taken into account.

Data sets uncertainty

The indicator is meant to give a representative overview of nutrient conditions in European rivers, lakes and groundwater. This means it should reflect the variability in nutrient conditions over space and time. Countries are asked to provide data on rivers, lakes and important groundwater bodies according to specified criteria.

The datasets for groundwater and rivers include almost all countries within the EEA, but the time coverage varies from country to country. The coverage of lakes is less good. It is assumed that the data from each country represents the variability in space in their country. Likewise, it is assumed that the sampling frequency is sufficiently high to reflect variability in time. In practice, the representativeness will vary between countries.

Each annual update of the indicator is based on the updated set of monitoring sites. This also means that due to changes in the database, including changes in the QC procedure that excludes or re-includes individual sites or samples and retroactive reporting of data for the past periods, which may re-introduce lost time series that were not used in the recent indicator assessments, the derived results of the assessment vary in comparison to previous assessments.

Waterbase contains a large amount of data collected over many years. Ensuring the quality of the data has always been a high priority. Still, suspicious values or time series are sometimes detected and the automatic QC routines exclude some of the data. Through the communication with the reporting countries, the quality of the database can be further improved.

Rationale uncertainty

Using annual average values provides an overview of general trends and geographical patterns in line with the aim of the indicator. However, the severity of shorter-term, high-nutrient periods are not reflected.

Data sources and providers:

Waterbase – Water quality ICM, available at the EEA Datahub. The processed data used for the indicator can be queried using the EEA Discodata platform under [WISE_Indicators].[v4r1].

Institutional mandate:

EEA AWP

DPSIR:

State

Topics:

Water and marine environment

Tags:

Nitrates; 8^{th} EAP; Freshwater quality; Lakes; Rivers; Groundwater; Phosphates; Phosphorous; WAT003

Temporal coverage

1992-2021

Geographic coverage

Albania

Austria

Belgium

Bosnia and Herzegovina

Bulgaria

Croatia

Cyprus

Czechia

Denmark

Estonia

Finland

France

Germany

Greece

Hungary

Iceland

Ireland

Italy

Latvia

Liechtenstein

Lithuania

Luxembourg

Malta

Montenegro

Netherlands

North Macedonia

Norway

Poland

Portugal

Romania

Serbia

Slovakia

Slovenia

Spain

Sweden

Switzerland

Turkey

Typology:

Descriptive indicator (Type A - What is happening to the environment and to humans?)

UN SDGs

6 – Clean water and sanitation

Unit of measure:

The concentration of nitrate is expressed as milligrams of nitrate per litre (mg NO_3/l) for groundwater and milligrams of nitrate-nitrogen per litre (mg NO_3-N/l) for rivers.

The concentration of phosphate in rivers is expressed as milligrams of phosphate-phosphorus per litre (mg PO_4-P/l) and total phosphorus in lakes is expressed as milligrams of phosphorus per litre (mg P/l)

The river sites are assigned to different concentration classes to visualise the distribution (percentage) of data in the dataset.

Frequency of dissemination:

Once a year

Contact:

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References

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3. Mann, H. B., 1945, 'Nonparametric Tests Against Trend', Econometrica 13(3), pp. 245–259 (https://www.jstor.org/stable/1907187) accessed March 25, 2022.

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5. Theil, H., 1992, 'A Rank-Invariant Method of Linear and Polynomial Regression Analysis', in: Raj, B. and Koerts, J. (eds), Henri Theil's Contributions to Economics and Econometrics: Econometric Theory and Methodology, Springer Netherlands, Dordrecht, pp. 345–381.

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