Nutrients in freshwater in Europe

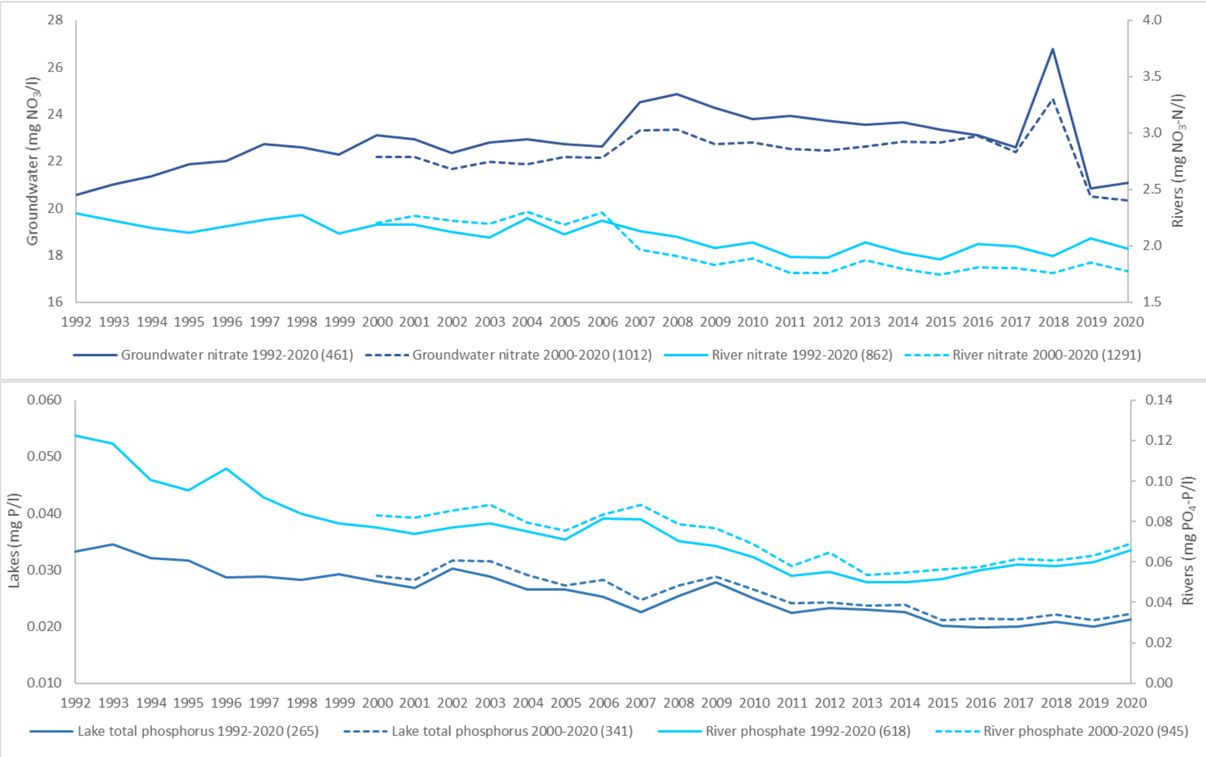
Last update 27/06/2022 – next update

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 waste water 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



Note:

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:

1992-2020: Europe (461), Austria (13), Belgium (24), Bulgaria (25), Denmark (1), Estonia (16), Finland** (7), France (247), Germany (66), Ireland (50), Portugal (2), Slovakia (4), Slovenia (5), Spain (1).

2000-2020: Europe (1012), Austria (14), Belgium (37), Bulgaria (40), Cyprus (6), Czechia (64), Denmark (4), Estonia (18), Finland** (8), France (437), Germany (175), Ireland (66), Italy (10), Latvia (15), Malta (2), Portugal (10), Serbia (21), Slovakia (16), Slovenia (6), Spain (26), Switzerland (37).

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

1992-2020: Europe (862), Albania (3), Austria (39), Belgium (26), Czechia (22), Denmark* (37), Estonia (34), Finland** (61), France** (184), Germany (119), Ireland** (4), Latvia (13), Lithuania (22), Poland (13), Slovakia (8), Slovenia (7), Spain** (153), Sweden* (111), Switzerland (6).

2000-2020: Europe (1291), Albania (7), Austria (41), Belgium (34), Cyprus (14), Czechia (22), Denmark* (38), Estonia (36), Finland** (70), France** (241), Germany (122), Iceland (1), Ireland** (50), Italy (25), Latvia (16), Lithuania (22), North Macedonia (18), Poland (16), Romania (89), Serbia (34), Slovakia (8), Slovenia (8), Spain** (250), Sweden* (113), 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:

1992-2020: Europe (618), Austria (27), Belgium (24), Bulgaria (32), Czechia (10), Denmark (39), Estonia (35), Finland (60), France (166), Ireland (4), Latvia (13), Lithuania (22), Norway (21), Slovakia (6), Slovenia (9), Spain (33), Sweden (111), Switzerland (6).

2000-2020: Europe (945), Albania (3), Austria (41), Belgium (28), Bulgaria (53), Croatia (23), Czechia (10), Denmark (40), Estonia (37), Finland (67), France (240), Iceland (1), Ireland (11), Italy (18), Latvia (16), Lithuania (22), Norway (21), Romania (88), Serbia (34), Slovakia (6), Slovenia (10), Spain (47), Sweden (113), Switzerland (16).

Total phosphorus in lakes: The number of lake monitoring sites included per country is given in parenthesis:
1992-2020: Europe (265), Austria (5), Denmark (5), Estonia (7), Finland (144), Germany (2), Lithuania (2), Netherlands (6), Norway (2), Slovenia (2), Sweden (90).
2000-2020: Europe (341), Austria (27), Belgium (1), Bulgaria (1), Croatia (3), Denmark (5), Estonia (8), Finland (168), 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 has been stable since 1992. The shorter, but more representative time series from 2000 follows the longer one closely, but the concentration level is slightly lower. The lack of a marked trend at European level does not imply limited changes in groundwater nitrate concentrations overall, but rather that the number of groundwater bodies (GWBs) with increasing and decreasing trends is similar.

Nitrate in rivers

The average river nitrate concentration in Europe decreased steadily over the period 1992-2009 but has levelled off since then. The shorter time series is parallel to the longer one, but the concentration level is lower from 2007 onwards. Agriculture remains the main contributor to nitrogen pollution, but the EU Nitrates Directive and national measures have contributed lower concentrations. However, the apparent stabilisation in recent years may call for further measures to be taken.

See chart for nitrate in groundwater and rivers here.

Phosphate in rivers

The average phosphate concentration in European rivers more than halved over the period 1992-2012. The marked decline is also evident for the shorter time series, but the average concentration is somewhat higher when using this larger set of sites. Concentrations tend to level off and even increase at the end of the period. The decrease in river phosphate can be related to measures introduced by national and European legislations, e.g. the Urban Waste Water Treatment Directive. Also, the change to phosphate-free detergents has contributed to lower phosphate concentrations.

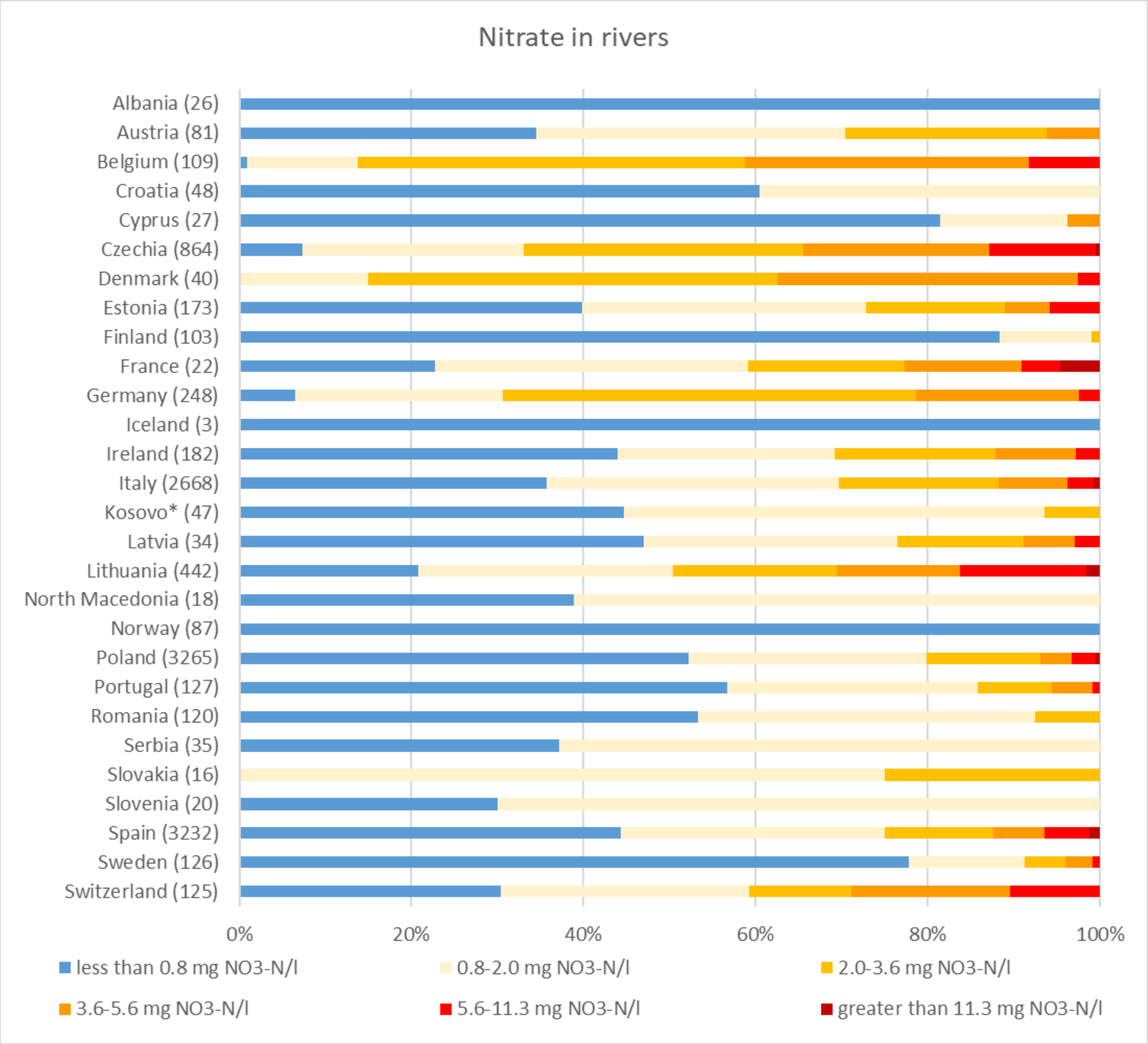
Total phosphorus in lakes

There has been a gradual reduction in average total phosphorus concentrations in European lakes since 1992. The concentration level is higher for the shorter, more representative time series. As the treatment of urban waste water has improved, the amount of phosphorus in detergents has been reduced, and many waste water outlets have been diverted away from lakes, 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.

See chart for phosphorus in rivers and lakes here.

Country level

Figure 2. Status of 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 2018-2020. 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). 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 2018-2020, Czechia and Lithuania had the largest proportion of river sites with average nitrate concentrations exceeding 5.6 mg NO_3-N/l (13% and 16%, respectively). Moreover, Belgium, Denmark, and Switzerland had a high proportion (more than 25%) of sites with concentrations exceeding 3.6 mg NO_3-N/l.

There has been a decrease in river nitrate concentrations at 47% of the monitoring sites since 1992, and an increase at 16% of the sites (Figure 1). Czechia, Denmark, Germany and Slovakia had the highest proportion of significantly decreasing trends (63-100%). France, Ireland, Spain and Switzerland had similar proportions of significantly increasing and decreasing trends, while Estonia had the highest proportion of significantly increasing trends (44%). An overall decline, although slowing in recent years, is observed for Austria, Belgium, Czechia, Denmark, Germany, Serbia and Sweden, contributing to the pattern seen in the European time series.

Supporting information

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 urban areas, industry and agricultural areas can lead to eutrophication. This causes ecological changes that can result in a loss of plant and animal species (reduction in ecological status) and can have negative impacts on the use of water for human consumption and other purposes.

Methodology

Annual mean concentrations are used as a basis in the indicator analyses. Unless the country reports aggregated data, the aggregation to annual mean concentrations is done by the EEA.

Automatic quality control procedures are applied both to the disaggregated and aggregated data, excluding data failing the tests 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[1] in the free software R[2], using the wql package. This is a non-parametric test suggested by Mann (1945)[3] and has been extensively used for environmental time series[4]. 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[5,6]. The same time series as for the time series analysis, but without gap filling.

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) sets the maximum allowable concentration for nitrate of 50mg NO3/l.

Reducing nutrient pollution from agriculture is an aspect of the European Green Deal, the 'Farm to Fork' 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. A revision of Waterbase reporting and the database-composition process took place in the period 2015-2017. This included restructuring of the data model and corresponding reporting templates; transformation of the legacy data (i.e. data reported in the past, for the period up to and including 2012); re-definition of specific data fields, such as the aggregation period defining the length of aggregation in a year; update of the datasets according to correspondence with national reporters; re-codification of monitoring site codes across Eionet dataflows; and connection of the legacy data time series with the newly-reported data in restructured reporting templates. 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

Institutional mandate
WISE SoE - Water quality (WISE-6)

Metadata

DPSIR
State

Topics
Nitrates; Phospates; Freshwater quality; Lakes; Rivers; Groundwater; Phosphorous; WAT003

Temporal coverage
1992-2020

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

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).

Frequency of dissemination
Once a year

Contact
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References and footnotes

1. Jassby, A. D., Cloern, J. E. and Stachelek, J., 2017, 'Exploring water quality monitoring data', (https://cran.r-project.org/web/packages/wql/vignettes/wql-package.html) accessed March 25, 2022.
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