European Topic Centre on Inland Waters

# SURFACE WATER QUALITY MONITORING

by

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# Preface

This report aims at elaborating an overview of the existing surface water quality monitoring activities in the countries in the European Environment Agency area (the 15 European Union Member States and Iceland and Norway). The study includes all surface waters, ie. rivers, lakes and reservoirs, coastal and open marine waters. The study is limited to the description of monitoring activities containing information of interest at European, Euro-regional, national or large regional level.

The report has been prepared by the National Environmental Research Institute (NERI) of the Danish Ministry of Environment and Energy based on a cost-shared project between the European Environment Agency Task Force of Directorate General XI Environment, Nuclear Safety and Civil Protection and NERI. A first draft report of this project was prepared for the Task Force in 1994 and preparation of the final report has been undertaken as part of project MW2 of the Multiannual Workprogramme 1994-99 of the European Environment Agency. As part of the activities of the European Topic Centre on Inland Waters (ETC/IW) this report has been updated during the spring 1995. With assistance of the ETC/IW partners, NERI has been responsible for the collating, evaluating and reporting of the information.

Opinions and views expressed in the present report are the responsibilty of NERI and they do not necessarily reflect those of the European Commission or the European Environment Agency.

# Acknowledgements

The report has been prepared and edited by Peter Kristensen and Jens Bøgestrand, both employed at the National Environmental Research Institute (NERI), Department of Freshwater Ecology. Furthermore, many persons and organisations in many countries (see Chapter 1) have made a great effort in preparation of national description of surface water monitoring activities as well as in commenting the draft version of the report. We would like to thank all contributors to this survey and we appreciate the time and effort spent in this respect.

We are also grateful to Paul Campbell, DGXI; Niels Thyssen, the European Environment Agency; Torben Moth Iversen, NERI; Henning Fjord Aaser, Ringkjøbing County and colleagues of the ETC/IW for their ideas and advice throughout the preparation of the report.

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# 1. Introduction, data and information sources

The European continent has several million kilometers of flowing water, more than a million lakes, and a long coastline, each having their own characteristics and, perhaps, environmental problems. An assessment of the general environmental state of European surface waters will be a compilation and aggregation of a huge amount of information. Such an assessment may be used to identify areas with severe environmental problems, to provide a basis for identification and assessment of environmental threats at regional and global levels, to provide information necessary to ensure that society develops in an environmentally sustainable way, and to enable general actions to be taken to improve the environmental state of the waterbodies.

Reliable high quality information about the environmental state of surface waters is essential for water management and implementation of optimal measures to improve environmental quality. Greater knowledge of water quality at the regional and European level is needed if European management of surface waters is to be improved. The reports "Europe's Environment - the Dobris assessment" (EEA 1995) and "European rivers and lakes - assessment of their environmental state" (EEA 1994) provided the first attempts to assess the environmental state of European surface waters. These reports included only a small part of the considerable quantities of environmental information currently produced. Moreover, the findings were based on heterogeneous information and not always directly comparable data as a consequence of, for instance, differences in the design of monitoring networks, variables selected, and analytical methods used. It is stated in the reports that the assessment could be significantly improved if more information could be included and measures were implemented to ensure consistency and comparability.

Considerable environmental information on European surface waters is currently collected and reported by various regional and national authorities. However, an overview of valuable information does not exist. In Europe local and regional authorities have traditionally been responsible for managing and monitoring the quality of surface waters. The activities were initiated in the 1960s and 1970s and were improved by the implementation of more and more monitoring activities and an increasing number of sampling sites during the 1980s. As the public demand for a cleaner environment and awareness of water quality issues increased during the late 1970s and 1980s the need for national and regional information on the environmental state of surface waters also increased. This situation led to the need for implementation of national surface water monitoring programmes. Many countries organized and established national aquatic monitoring programmes in the late 1980s and early 1990s. Nearly all countries in the EEA area have now, for instance, a national monitoring programme with the purpose of assessing the chemical and physical conditions of rivers. Various marine monitoring activities have also been coordinated, standardized and harmonized to be included in national marine monitoring programmes.

The results from these national and large regional surface water monitoring programmes may form the basis of a surface water quality information system in the EEA area. The first step is to work out an overview of the existing data sources on the environmental state of European surface waters. This report is a part of this process and aims at elaborating an overview of the existing surface water monitoring activities in the countries in the EEA area (the current 15 EU Member States plus Iceland and Norway). The study includes all surface waters, ie. rivers, lakes and reservoirs, coastal and open marine waters. The study is limited to the description of data sources containing information of interest at European, Euro-regional, national or large regional level (Länder, water boards, etc.). The report includes a description of the national and large regional surface monitoring programmes in each country. Similar monitoring programmes have been put together and similarities and differences according to network set-up, sampling frequency and variables measured have been analyzed.

On the basis of the report and additional analyses, a European surface water information system may be elaborated, including criteria for incorporating national monitoring sites into the international network, proposals for harmonization and standardization of sampling and variables to be analyzed, and ideas for information processing from the national level to EEA level. Such a system should be established in close cooperation with the participating countries.

The report has been prepared by the National Environmental Research Institute (NERI) of the Danish Ministry of Environment and Energy based on a cost-shared project between the Commission of the European Community (CEC) and NERI. In December 1993 the CEC, DGXI.B1 and EEA-TF, respectively, entered into a contract with NERI. A draft report of this project was prepared in November 1994. As part of the activities of the European Topic Centre on Inland Waters (ETC/IW) this report has during the spring 1995 been updated. NERI has with assistance of ETC/IW partners been responsible for collating, evaluating and reporting the information.

## 1.1 Sources of data and information

The data and information in this report are based on:

- nationally prepared descriptions of major surface waters and the administrative organization of surface water quality monitoring (involved organizations, responsibilities, coordination, reporting, data storage, etc.),
- national descriptions of major national and large regional surface water monitoring programmes,
- various national and regional state of the environment and technical reports, and
- scientific literature on monitoring of surface waters.

The National Environmental Research Institute (NERI), Denmark, started working on the project in January 1994. During the spring NERI produced a list of elements to be studied by each Member State and also worked on case studies of monitoring activities in Ireland and Denmark. A draft report describing the Irish monitoring activities was distributed to the Member States as a proposed outline of the descriptions to be prepared by each Member State. On June 22 a meeting was held by the EEA-TF in Brussels with representatives from 11 countries. The outline was discussed and it was decided that NERI should prepare a revised outline and send it to the national focal points and that each country should prepare a description of national monitoring activities and forward the descriptions to NERI by August 15. During the autumn of 1994 NERI received descriptions of monitoring activities from several countries. NERI analyzed the description and prepared in November 1994 a draft report. The draft report has in January 1995 been distributed to the Member States and ETC/IW partners for their comments and for updating with additional monitoring activities. Comments, information about additional monitoring programmes and suggestions for improvements were received from the Member States and ETC/IW partners during the early spring 1995. NERI has incorporated the comments and updated the report with the new monitoring programmes.

Many persons in many countries have made a great effort to prepare descriptions of the national surface monitoring activities, and they are gratefully acknowledged. Table 1.1 lists the organizations and persons who have contributed. Sixteen countries were kind enough to prepare national descriptions of their monitoring activities including specific descriptions of more than 100 monitoring programmes. However, the information supplied differed greatly: some countries provided only little information (a few written pages or report references), while others supplied very extensive descriptions with detailed information on the organizations in charge of monitoring activities and several detailed descriptions of monitoring programmes (more than 100 pages). *No information has been provided from Italy.*

**Table 1.1:** Persons and organizations responsible for preparing the descriptions of monitoring activities

| **Country** | **Name** | **Organization**<br>**Address** | **Telephone**<br>**[Telefax]** |
|---|---|---|---|
| **Austria** | W. Vogel | Umweltbundesamt<br>Spittelauer Lände 5<br>A-1090 Wien | +43 1 31304-0<br>[+43 1 31304-400] |
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| **Denmark** | J. Bøgestrand<br>K. Brodersen<br>P. Kristensen | NERI<br>Ministry of Environment and Energy<br>National Environmental Research Institute<br>P.O. Box 358<br>Dk-4000 Roskilde | +45 46 30 12 00<br>[+45 46 30 12 14] |
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| | | | |
|---|---|---|---|
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| **Italy*** | | | |
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| **The Netherlands** | P.J.M. Latour<br>W.H. Mulder | Ministry of Transport, Public Works and Water Management<br>Directorate-General For Public Works<br>Institute for Inland Water Management and Waste Water Treatment, RIZA<br>P.O.box 17<br>8200 AA Lelystad | +31 32 00 70 411<br>[+31 32 00 49 218] |
| **Norway** | A. Solås<br>B. Kväven<br>G. Kielland<br><br>B. Faafeng | SFT<br>Norwegian Pollution Control Authority<br>P.O. Box 8100 Dep<br>N-0032 Oslo<br>NIVA<br>Norwegian Institute for Water Research<br>P.O.Box 173, Kjelsås<br>N-0411 Oslo | +47 22 57 34 00<br>[+47 22 67 67 06]<br><br><br>+47 22 18 51 00<br>[+47 22 18 52 00] |
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| | | | |
|---|---|---|---|
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* No information from Italy

In total, information on 61 river or inland water monitoring programmes, 19 lake monitoring programmes and 41 marine monitoring programmes has been collected. Most of the monitoring programmes aim at measuring the quality and pollution in the water column, and the majority of the monitoring programmes focus on chemical and physical assessment of water quality. A number of monitoring programmes use sampling of biological organisms, especially macroinvertebrates in rivers and plankton in lakes and marine areas, respectively. Programmes focusing on harmful substances often includes analyses of pollutants in sediment and biota, the most commonly employed organisms being fish and shellfish.

The report does not describe all surface water monitoring activities performed by the EEA Member States, since many other organizations (especially at the regional and local level) undertake monitoring as well. Nevertheless, it aims at providing an overview of the major national monitoring activities.

## 1.2 Presentation of results

Many of the descriptions of monitoring activities prepared by the countries were very extensive documents including much detailed information, and when put together as summaries in this report some information had to be omitted. In chapter 3 NERI has tried to prepare comparable summary descriptions of the monitoring activities in each country based on the national descriptions supplied (frequently as direct copies of parts of the supplied information). In some cases the summary descriptions may be faulty due to insufficient information.

In the text and tables presented there may be some uncertainty as to factual information, and incorrect figures and values may appear. The errors are mainly due to mistakes made by NERI or lack of information. Furthermore, it has been necessary to simplify and condense information and consequently omit details to enhance comparability. For example, it may be stated that a monitoring programme includes 200 sampling sites at which monthly measurements of heavy metals are made, but heavy metals may, in fact, be measured at 25 per cent of the sampling sites only. **Please take note of this and use the information presented in the report as a general overview rather than as exact information on specific monitoring programmes.**

In some cases the countries have not supplied sufficient information on their national monitoring activities. Some countries with a long coastline have, for instance, not supplied information on marine monitoring programmes. Therefore, the report does not give a complete overview of the monitoring activities in the EEA Member States.

A code has been used when referring to specific monitoring programmes, ie. "CC-Xn", CC referring to the country (see Table 1.2), X being either R=river, L=lake, or M=marine, and n is a numerical value. For example, DK-R1 refers to Denmark and to river monitoring programme number one.

**Table 1.2:** Countries and country codes in the European Environment Agency area.

| Country | Country code |
|---|---|
| Austria | AU |
| Belgium | BE |
| Denmark | DK |
| Finland | FI |
| France | FR |

| | |
|---|---|
| Germany | DE |
| Greece | GR |
| Iceland | IS |
| Ireland | IE |
| Luxembourg | LU |
| The Netherlands | NL |
| Norway | NO |
| Portugal | PT |
| Spain | ES |
| Sweden | SE |
| United Kingdom | UK |

# 2. Surface water quality monitoring

This chapter aims at giving a short introduction to the basic principles of surface water monitoring. Additional information can be found in numerous textbooks, an example being “Design of Networks for Water Quality Monitoring” by Sanders et al. (1987).

The objective of water quality monitoring is to obtain quantitative information on the physical, chemical, and biological characteristics of water via statistical sampling (Sanders et al. 1987). The type of information sought depends on the objectives of the monitoring programme. Objectives and purposes range from detection of drinking water standard violations to determination of the environmental state and analysis of temporal water quality trends. Three categories of monitoring can be identified: (1) routine surface water monitoring, (2) periodic special surveys, and (3) special surveys performed to assess the extent of a pollution problem (eg. a survey of pesticide occurrence in surface waters).

The state of water quality is the result of complex natural and man-made conditions and the consequent interactions in both time and space. Consequently, abstracting the essence of water quality conditions is often very difficult. Monitoring and assessment of the environmental state of European surface waters are performed by numerous local, regional and national authorities. The wide variety of organizational structures pertaining at the national and local level in European countries means that administration of monitoring activities differs greatly. Looking at national large-scale regional surface water quality monitoring programmes as an important information source, it is important to know the main components of the organizational structure involved, eg. participating institutions and their responsibilities, the overall coordination principles of monitoring, data storage, reporting of information, etc.

**Monitoring purposes**
Any attempt to evaluate water quality monitoring programmes should begin with the question "Why do we monitor?" It is very important to be able to describe the purposes and objectives of monitoring as they create the background for the direct monitoring activities, ie. the set-up of sampling networks, variables to be measured, sampling frequency, data storage and information utilization, including data analysis and reporting.

The purpose of monitoring is generally laid down by laws or other regulatory actions (directives, water quality standards, action plans) and aim at assessing the environmental state and detecting trends. The regulatory actions set up water quality goals or standards (eg. a 50 per cent reduction of nitrogen loading to surface waters, no pesticides in drinking water, etc.), and the purpose of monitoring is to supply data and information on the water quality in relation to these regulatory actions.

Many monitoring programmes serve several purposes. One-purpose monitoring programmes may when new laws are passed deal with additional aspects of water pollution or new approaches to water quality management, and thus be expanded to supply additional data and information.

Objectives as the ones described above represent one dimension of the monitoring system. Another dimension is associated with the activities involved in data acquisition and utilization of information. These activities begin with the collection of samples and end with informing the public on the findings and using the results to implement measures to improve the environmental state of the waterbody.

Data acquisition can be described by the monitoring sampling network, the sampling frequency, and the water quality variables measured, while information utilization can be described by data storage, data analysis and reporting procedures. In the following these activities are described.

**Monitoring network design**

The monitoring network is above all described by the waterbodies (ie. springs, brooks, streams, rivers, river systems, ponds, lakes, reservoirs, fjords, estuaries, coastal area, or open marine water) and the geographical area (eg. country, river system, etc.) it covers. However, more specific information on the criteria for selection of sampling sites is often necessary to evaluate the information obtained from a monitoring programme. Two types of networks can be identified: (1) an extensive network involving many sampling sites, few annual samples, analyses of a few variables, and only one or few years of sampling, (2) an intensive network including sampling sites with detailed investigations, many annual sample or measurement of many variables, and many years of observations. Many monitoring networks are both intensive and extensive, for example, a sub-network consisting of many extensive sampling sites with few variables combined with a sub-network including relatively few sampling sites with frequent sampling and several variables measured.

River sampling networks must be described by the strategy for the selection of sampling sites; eg. major rivers in a country or frequent sampling downstream point sources. A general description of the total number of sampling sites, number of rivers, number of river systems and information on catchment areas (eg. catchment area size distribution) generally give a fair description of the sampling network. Many river sampling networks are composed of two or more sub-networks, eg. a few intensive sampling sites located in major rivers and numerous basic sampling sites located at less important tributaries and river reaches.

Lake sampling networks must also be described by the strategy for the selection of sampling sites (ie. largest lakes, or lakes from known problem areas featuring, for instance, eutrophication or acidification, etc.). Many lake monitoring programmes are based on surveys of the environmental state of lakes made at five year intervals, the lakes to be included into the survey either being fixed or selected by use of statistical criteria among the total number of lakes in a country. Often the survey programme is supplemented with an intensive lake monitoring programme involving annual studies of relatively few lakes..

Marine sampling networks are generally described by the specific marine areas in which sampling sites are located (eg. the name of estuarine areas or name of the sea), and the number of coastal and offshore sampling sites. Marine monitoring programmes often have several sub-networks, for example, one sampling network for taking water samples, one network for sampling bottom fauna, and one network for investigation of macrophytes.

**Variables measured**

The number of variables describing the quality of a waterbody have increased and are constantly being modified and further refined along with the expanding uses to which water is put, and also in pace with the development of analytical capabilities to measure more and more substances at ever lower concentrations.

The various groups of water users have, to some extent, developed their own approaches and methods to describe and measure water quality. For many decades river basin management and water pollution control have relied on summary variables, such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD) to quantify sewage discharge and oxygen problems in rivers. For the purpose of human consumption and public water supply, a set of microbiological indicator organisms (eg. faecal coliform bacteria) have been identified and their enumeration is now commonly applied to determine the hygienic suitability of water for drinking.

The water quality variables can be grouped into the following broad categories:

- Basic variables (eg. water temperature, pH, conductivity, dissolved oxygen, and discharge) used for a general characterization of water quality.
- Suspended particulate matter (eg. suspended solids, turbidity and organic matter (TOC, BOD and COD)).
- Organic pollution indicators (eg. dissolved oxygen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonium).
- Indicators of eutrophication: nutrients (eg. nitrogen and phosphorus), and various biological effect variables (eg. chlorophyll a, Secchi disc transparency, phytoplankton, zoobenthos).
- Indicators of acidification (eg. pH, alkalinity, conductivity, sulphate, nitrate, aluminium, phytoplankton and diatom sampling)
- Specific major ions (eg. chloride, sulphate, sodium, potassium, calcium and magnesium) as essential factors in determining the suitability of water for most uses (eg. public water supply, livestock watering and crop irrigation)
- Metals (eg. cadmium, mercury, copper and zinc)
- Organic micropollutants such as pesticides and the numerous chemical substances used in industrial processes (eg. PCB, HCH, PAH).
- Indicators of radioactivity (eg. total alpha and beta activity, $^{137}Cs$, $^{90}Sr$)
- Microbiological indicator organism (eg. total coliforms, faecal coliforms and faecal streptococci bacteria)

- Biological indicators of the environmental state of the ecosystem (eg. phytoplankton, zooplankton, zoobenthos, fish, macrophytes and birds and animals related to surface waters).

*Matrices sampled*
Most of the monitoring programmes measure the quality and pollution in the water column and some of the monitoring programmes also include sampling of other compartments of the aquatic environment, especially pollutant analysis of the sediment and of particulate matter. Biological indicator organisms and analysis of the various biological communities are used to assess the ecological state of the waterbodies. The biological indicators most employed in river quality investigations are large visible invertebrates (macroinvertebrates), while the biological indicators most employed in lake and coastal water investigations are studies of phytoplankton (algae) and zoobenthos.

**Sampling frequency**
The sampling frequency differs substantially depending on the purpose of the monitoring programme and the variables to be measured. Frequent samples are generally taken when the purpose of a monitoring programme is to observe trends, while programmes and surveys with the purpose of assessing the general state of many waterbodies generally are based on low sampling frequency. Some monitoring programmes include continuous registration of basic variables such as pH, conductivity, salinity and dissolved oxygen, while in most monitoring programmes measuring the quality and pollution in the water column, a number of annual samples are taken. Investigation of biological organisms such as macroinvertebrates in rivers and zoobenthos in lakes and marine areas is usually based on few annual samples. A large proportion of the costs of operating a monitoring programme is directly related to the sampling frequency.

The sampling frequency can be described by the total number of annual samples, for example 12/yr: twelve samples a year; or 2/5 yr: two samples every five years. Information on the timing of sampling may also be important, if sampling is evenly spread throughout the year (eg. monthly, weekly samples) or if stratified sampling is used (eg. sampling during summer, pesticide spraying seasons or peak flow periods; monthly sampling every fifth year).

**Data storage and data analysis**
Generally the national monitoring programmes are organized so that the local authorities are responsible for the data acquisition. For example, in the national French river monitoring programme the six basin agencies are responsible for data acquisition in their respective areas, or in Germany the Länder have the responsibility for environmental issues in their region including monitoring of surface waters. In many cases only summary data (eg. annual mean values or grades assigned to the quality of a specific waterbody) are reported to the organizations responsible for national reporting, while the raw data is stored at the organizations responsible for data acquisition. This accumulation of aggregated data at the national level often make comparison of results from the various countries difficult due to different methods used for data analysis and aggregation of data. Consequently, information on data analysis and data storage procedures is important when evaluating the national monitoring programmes.

**Reporting and utilization of information**
In the last five to ten years the number of national state of the environment reports have increased substantially. Nearly all countries prepare either annually or with intervals of two to five years various reports including a national assessment of the environmental state of surface waters. The reports are generally based on the information produced by the national monitoring programmes supplemented with additional information from more specific investigations.

# 3. Summary description of surface water monitoring activities in each country

**Introduction**
The following chapter aims at giving an overview of monitoring activities in the 16 countries from the EEA-area having supplied information. The monitoring activities of each country are briefly summarized. First the main surface waters of each specific country are described. Secondly, an overview of the involved institutions and the organization of surface water monitoring activities is presented. Finally, the main monitoring activities in relation to rivers, lakes, coastal and marine waters are described including a table listing:
- name of the monitoring activity,
- involved institutions,
- measured variables,
- period of operation and sampling frequency,
- geographical coverage
- data storage and reporting.

A list of the involved institutions is given in appendix II.

These summary descriptions of the monitoring activities of each county are very compressed compilations of the more extensively descriptions (at present more than 1000 pages in total) prepared by each country. In appendix I more detailed tables of the monitoring activities are presented. In addition, the more detailed specific descriptions of each monitoring activity will be stored in the EEA Catalogue of Data Sources (EEA-CDS).

**Fig.1.** *Map of Europe. Countries in the EEA-area covered by this inventory coloured grey.*

# Austria

Austria has a land area of 83,856 $km^2$ and a population of 7.8 million (1991). The Alps cover two thirds of the Austrian territory. 96 per cent of the land area is a part of the Danube catchment, 38 per cent of the catchment area is confluent with the Danube outside the Austrian territory (eg. the rivers Mur, Drau, Leitha, and Raab). The total river length is about 100,000 km and 30 rivers have a catchment area exceeding 1,000 $km^2$. Austria has about 9,000 lakes and ponds (62 per cent natural and 38 per cent artificial), 26 of the lakes have a surface area larger than 1 $km^2$. The two largest lakes, Lake Constance and Lake Neusiedler See have a surface area exceeding 300 $km^2$ and are shared with Switzerland and Germany, and Hungary, respectively.

**Involved institutions**
In Austria - being a federal republic - the responsibilities are shared between federal authorities and the 9 provinces (Bundesländer). Responsibility in water affairs including water quality monitoring is concentrated within the Federal Ministry of Agriculture and Forestry/Division IV (Water management and hydraulic engineering) cooperating with its Federal Agency for Water Management and the Federal Environmental Agency.

The Federal authorities are responsible for legislation, coordination and standardization of national monitoring programme, the provincial authorities being responsible for the actual operation of the water monitoring programme. Table 3.1 lists the main Austrian surface water monitoring programmes.

**River Monitoring**
In Austria water quality monitoring has a long tradition. Maps concerning the river quality indicated as water quality class have been published by the Federal Ministry of Agriculture and Forestry nearly every two years since 1962, but up to 1990 there has not been a definite, nation-wide programme for water quality monitoring of surface waters.

In 1990, in connection with the comprehensive amendment of the Federal Austrian Water Act, the Federal Act on Hydrography was extended to include the investigation of water quality. This act provides the legal and financial basis for the establishment of a nation-wide, systematic water quality monitoring system for ground water and running waters (R1).

*Ordinance on Water Quality Monitoring (R1)*
Details of the monitoring programme are laid down in an "Ordinance on Water Quality Monitoring". The main features of the monitoring system are to provide up-to-date and detailed information on ground water and river water quality to decision makers and the general public. Thus
- changes in water quality are indicated very quickly,
- the main areas of pollution can be detected and remedial measures carried out effectively,
- the progress of remedial measures can be supervised by monitoring.

The provincial authorities are responsible for the operative execution of the water monitoring programme (eg. selection of sampling sites, sampling, analyzing, etc.). Sampling and analyzing are entirely undertaken by private subcontractors invited to tender by the provincial authorities. The contractors are kept under close surveillance (Federal Ministry of Agriculture and Forestry/Department of Water Management Register and the provincial authorities) to assure the quality of sampling and analyses.

**Table 3.1:** Austrian national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (GREENED) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Ordinance on Water Quality Monitoring | MAF | physical, chemical, bacteriological & biological variables | since 1991<br>SF: 6/yr | 244 sampling sites at national rivers | Database & reporting; MAF-WMR & FEA |
| R2-R8 | Water quality monitoring of transboundary rivers<br>2. Bucharest Declaration<br>3. Regenburger Vertrag<br>4. AU-CZ Grenzgewässer-kommision (GK)<br>5. AU-SK GK<br>6. AU-HU GK<br>7. AU-SL GK river Mur<br>8. AU-SL GK river Drau | BfW & the commissions, respectively | physical ,chemical & biological variables | 2. since 1988<br>SF: monthly<br>3. AU-DE since 1991<br>SF: monthly<br>4. AU-CZ since 1968<br>SF: 1-4/yr<br>5. AU-SK since 1968<br>SF: every 2 months<br>6. AU-HU since 1972<br>SF: 2-12/yr<br>7. AU-SL since 1965<br>SF: 2/yr<br>8. AU-SL since 1955<br>SF: 1/yr | 2. 2 sites at Danube<br>3. Rivers crossing AU-DE border<br>4. Rivers crossing AU-CZ border<br>5. Rivers crossing AU-SK border<br>6. Rivers crossing AU-HU border & Lake Neusiedler See<br>7. River Mur<br>8. River Drau | AU database; BfW Database & reporting by the commissions, respectively |
| **Lakes and reservoirs** | | | | | | |

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| L1 | Water quality monitoring according to the "trans-boundary commission" for Lake Constance | IKGB | physical, chemical & biological variables | since ?<br>SF: differs according to the special monitoring programme | Lake Constance & tributaries | Database & reporting; IKGB |
| L2 | Gewässergüteuntersuc-hungen Zeller See | BfW | physical, chemical, bacteriological & bio-logical variables | since 1953<br>SF: 5/yr | Lake Zeller See | Database & reporting; BfW |

AU: Austria; SK: Slovak Republic; SL: Slovenia; DE: Germany; CZ: Czech Republic; HU: Hungary
MAF: Federal Ministry of Agriculture and Forestry; WMR: Water Management Register; FEA: Federal Environmental Agency;
BfW: Bundesanstalt für Wassergüte; IKGB: Internationalen Gewässerschutz-Kommission für den Bodensee

River water samples are collected six times a year (every two months), sediments as well as biological material are sampled once a year. At some sampling sites water samples are taken twelve times a year because of special bilateral agreements on transboundary water management issues.

The substances observed can be divided into three units: the first one covers all substances necessary for a general characterization of hydrochemical properties or general pollution situations (oxygen, nutrients, pH, etc.). The substances of the second group serve to provide an Austrian-wide survey (heavy metals, hydrocarbons, AOX). The third unit covers i.a. substances with high ecotoxicological relevance such as pesticides. The selection of substances is adapted to regional requirements and depends on the specific land use and of state of pollution.

Full compatibility of information is enforced with the help of technical guidelines and directives. All data are stored at the Federal Environmental Agency. Data are evaluated by both partners, the Federal Ministry of Agriculture and Forestry and the Federal Environmental Agency in close cooperation. Summarized results are published in annual reports by the Department for Federal Water Management Register.

**Monitoring of transboundary rivers**
Austria has signed agreements with neighbouring countries and international treaties concerning the protection and improvement of water quality and cooperation in water management in the border sections. A number of transboundary commissions were set up to put the agreements into practice. River water quality is investigated according to the monitoring programmes defined by the special transboundary commissions (R2-R8).

**Monitoring of lakes**
Up to now there is no standardized programme on water quality monitoring of Austrian lakes. The water quality of Austrian lakes is investigated within the scope of special monitoring programmes of provincional authorities and research programmes (Academy of Science, University institutes, Federal Institute for Water Quality). Some lakes have been continuously investigated since 1960, but the variables investigated and the sampling frequency vary a lot. In addition to the "Ordinance on water quality monitoring" for rivers and groundwater, the Federal Ministry of Agriculture and Forestry will also work out a special ordinance for monitoring water quality of the most important Austrian lakes.

Austria participates in the L1 monitoring programme for Lake Constance coordinated by the Internationalen Gewässerschutz-Kommission für den Bodensee (IGKB/ Lake Constance), and also Zeller See has been continuously monitored since 1953 (L2).

# Belgium

Belgium is bounded by Germany, Luxembourg, France, the North Sea and the Netherlands. It has an area of 30,500 $km^2$ and a population of 10 million. Belgium is divided into three regions: the Flanders region, the Brussels region and the Walloon region.

Belgium is primarily drained by two large river systems, the river Meuse and the river Schelde that drain approx. 44 and 33 per cent of the total land area, respectively. Both rivers arise in France and run north, the Schelde draining the western part of Belgium and discharging into the Schelde Estuary, while the Meuse with tributaries in Germany drains the eastern part of Belgium and runs north into the Netherlands where it discharges near Rotterdam. The Albertkanal connects city of Antwerpen and the river Meuse. There are only few natural lakes in Belgium. Belgium has a 60 km long coastal zone (North Sea).

**Involved Institutions**
Due to the changes in the constitution, Belgium has been divided into three regions, each of them responsible for environmental affairs.

*Flanders region*
The Flemish Environmental Agency (the 'Vlaamse Milieumaatschappij' - VMM) is a para-governmental institution complementary to the environmental administration. One of the important tasks of the VMM is to establish and run the monitoring programme on surface water quality. The VMM also runs the monitoring programmes on industrial and urban discharge and ambient air quality. The VMM calculates rates and collects taxes on water pollution. Another task of the VMM is the annual publication of the results of the monitoring programmes. The VMM also acts as an advisory body to the Administration of the Environment, Nature and Land Planning (AMINAL) with regard to discharge permit procedures.

The main objectives of the water quality monitoring network are :
1) measurement of the parameters for which water quality objectives have been set;
2) determination of the water quality by means of indices and water quality classes;
3) discovery of unknown discharges and determination of the origin of specific pollutants and their impact upon water quality;
4) comparison of measurement data with water quality standards;
5) annual compilation of the pollution loads per (sub)hydrographic basin.

Since 1989 the VMM physico-chemical monitoring network (R1) has consisted of more than 1,600 sites in the Flemish water - courses ranging from canals and navigable rivers to municipal water courses. The basic variables measured are: temperature, dissolved oxygen concentrations, chemical oxygen demand, nitrogen (NH4-N, NO2-N, NO3-N), phosphate, total phosphorus, chloride, conductivity and pH. For a selected number of sites the following variables are added: Biochemical Oxygen Demand, Kjeldahl-nitrogen, sulphates and suspended matter. The annual sampling frequency ranges from 8 to 12. Heavy metals are measured only at locations in the vicinity of industrial discharges and regional borders. The samples of the physico-chemical monitoring network are taken by different regional laboratories.

Since 1989 the VMM biological monitoring network (R2) has consisted of 1,300 different sites at which a Belgian Biotic Index (BBI) based on the presence of aquatic macroinvertebrates as water quality indicators is applied. The diversity and relative sensitivity of these macroinvertebrates are a measure of the degree of pollution at the sampling location. Biological monitoring network samples are all taken by VMM biologists.

*Walloon region*
The Division de la Police de l'Environnement (DPE) is the institution responsible for monitoring activities in the Walloon region. The DPE carries out physico-chemical and biological monitoring throughout the region. The general physico-chemical network (R5) consists of 90 monitoring sites being sampled 5 times annually, and 7 transboundary sites that are sampled monthly. The transboundary sites are included in the EU Information Exchange Programme. A total of 108 variables are measured at most sampling sites and the results are published as annual administrative reports and periodic thematic quality index maps on organic pollution. The R6 programme covers 49 waterbodies designated as protected. Sampling frequency is usually monthly and between 16 and 28 variables are measured. The biological monitoring programme (R8) covers approx. 410 sites in the running waters of the Walloon region. In addition to the Belgian Biotic Index of macroinvertebrates, phytoplankton and macrophytes and a few basic physico-chemical variables are determined. The programme consists of a general part, a protected waters part (corresponding to R5, R6) and a case-study part (industrial pollution). As for the physico-chemical network administrative reports and quality index maps are published. There is no separate lake monitoring programme, but some reservoirs are included in the general river monitoring programme (R5).

**Table 3.2:** Belgian surface water monitoring programmes

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & national reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Physico-chemical monitoring network | VMM | 11-16 physical and chemical variables | Since 1989<br>SF: 8-12/yr, sometimes 26-52/yr | Flanders region<br>1000 sampling sites | Database and annual report: VMM |
| R2 | Biological monitoring network | VMM | Macroinvertebrates, Belgian Biotic Index | Since 1989<br>SF: 1/yr. | Flanders region<br>900 sampling sites | Database and annual report: VMM |
| R3 | Measuring network suspended solids | VMM | Water & suspended solids: organic micropollutants & heavy metals | Since: Sep. 1994<br>SF 3/yr | Flanders Region<br>20 sampling sites | Reports after each campaign |
| R4 | Measuring network water soils | VMM | Heavy metals & organic micropollutants | Study undertaken in 1991-92 and will be repeated in 1995-1996 | Flanders Region | Reports after each campaign |
| R5 | Physico-chemical monitoring of surface waters | DPE | Up to 108 physical and chemical variables | 1. network: 5/yr.<br>2. network: 12/yr | Walloon region<br>1.network: 90 sites covering main rivers, stre- | Database & annual report: DPE. |

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| | | | | | ams, canal, and reservoirs.<br>2. network 7 sites on transbordering water courses | |
| R6 | Physico-chemical monitoring of designated protected waters 3 networks<br>1) Freshwater for fish<br>2) Surface water for drinking water<br>3) Natural water networks | DPE | 16-28 physical & chemical variables | 1) 12/yr<br>2) 2-8/yr<br>3) 12/yr | Walloon region.<br>1) 38 sampling sites,<br>2) 5 sampling sites<br>3) 6 sampling sites | Database & annual report: DPE. |
| R7 | Alarm network. | DPE | 6-12 physical & chemical variables | continuous (every 3 minutes) | River Meuse, 3 sites.<br>River Sambre, 2 sites. | Database & annual report: DPE. |
| R8 | Biological quality assessment of water courses | 1980-92:IHE<br>1993-: DPE | Macroinvertebrates, Belgian Biotic Index, 5 physical & chemical variables | once every 3 years.<br>case-studies: according to occurance | Walloon region.<br>200+150+60 sampling sites | Database & annual report: DPE. |
| R9 | Bathing water | 1982-89: IHE<br>1990-: DPE | physical, chemical & microbiological variables | 9 samples from mid-May to mid-September | Walloon region<br>47 sampling sites in fresh surface water | Database & annual report: DPE. |
| R10 | Hydrometric networks. | DPE & SETHY | flow, water height | 4 measures per hour | Walloon region<br>103+145 hydrometric stations. | Database: DPE & SETHY |

VMM - Flemish Environmental Agency / Vlaamse Milieumaatschappij; IHE - Institute for Hygiene and Epidemiology; DPE - Division de la Police de l'Environnement; SETHY - Ministére de l'Equipement et des Transport

# Denmark

Denmark has a total land area of 43,000 $km^2$. The population of Denmark constitutes 5.1 million, the population density accordingly being 120 inhabitants per $km^2$. The long coastline of Denmark in proportion to its area means that it is dominated by a large number of small river catchments and short rivers. The three largest rivers only drain about 14 per cent of the land area. Denmark has 468 lakes with an surface area greater than 0.05 $km^2$ (5 ha). The typical Danish lake is small, shallow and has a short water residence time. The coastline is 7,300 km long and one quarter of the coastline borders the open sea (ie. the North Sea and the Skagerrak). The remaining three quarters of the coastline borders fjords, estuarine areas and semiclosed coastal areas (eg. the Kattegat, the Belts and the Baltic).

**Surface water quality monitoring**

*Involved institutions*
Surface water monitoring in Denmark has been undertaken since the early 1970s. The 14 Danish counties have been responsible for inland surface water and coastal water monitoring and management, while the Ministry of Environment and Energy is responsible for monitoring the marine areas. During the 1970s and 1980s much information on the environmental state of surface waters was collected and reported by the counties. The use of information on a national level was, however, rather limited, primarily because the previously decentralized Danish monitoring was suffering from widely differing regional efforts, differing staff qualifications, incommensurable methods, differing sampling strategies, etc. This situation changed when the nation-wide monitoring programme was established in 1988.

In 1987 the Danish Government passed the Action Plan on the Aquatic Environment. The main objectives of the Action Plan are to reduce the nitrogen and phosphorus discharge by 50 and 80 per cent, respectively. In connection with the Action Plan it was decided to establish a monitoring programme to observe the reduction in discharge of nutrients and monitor the effects on the biological communities in the aquatic environment. The programme assembles nation-wide information on the sources and distribution of nutrients in inland waters (groundwater, rivers and lakes) and the nutrient loading of the marine environment. In addition, the programme provides information on the water quality of ground water, inland surface waters and marine waters. The Danish Environmental Protection Agency has the overall responsibility for the monitoring programme.

In order to obtain the above information, monitoring sites have been established at locations all over Denmark in connection with a comprehensive sampling programme. The regional authorities (the 14 Danish counties) are responsible for monitoring groundwater, rivers, lakes and coastal waters, while the National Environmental Research Institute (NERI) is responsible for monitoring the open sea and the atmospheric deposition. NERI and Geological Survey of Denmark (GSD) have the responsibility of national planning, coordination, and national annual reporting of the environmental state of the aquatic environment. The counties report the results of their monitoring activities annually, and these reports together with key data are the basis for the national environmental reports. The national authorities ensure through advising, technical meetings, and technical guidelines appropriate operation and coordination of the various monitoring activities. Consistency and comparability of information processed is ensured by national coordination and guidelines and technical reports on monitoring, sampling frequency, variables to be measured, etc. The monitoring programme has in all significantly improved the information basis for decisions to be taken in relation to the environmental state of the aquatic environment.

**Rivers and streams**
The nation-wide aquatic monitoring programme includes three river monitoring programmes R1-R3. The general river monitoring programme R1 has two main purposes; a network comprising 238 sampling sites provides detailed information on nutrient loading and biological conditions of rivers draining various representative catchments (eg. forest and natural, agricultural, and urban), whereas a network comprising 130 sampling sites in 125 river systems provides an overall estimate of nutrient loading to Danish coastal waters. Many sampling sites are included in both networks, the river networks consisting of totally 261 sampling sites in 240 rivers and 125 river systems. Water samples are taken at fortnightly to monthly intervals and analyzed for general chemical and physical variables. The R2 monitoring programme aims at establishing information on the water quality of springs and brooks and the network consists of sampling sites in 58 springs, of which 45 are situated in agricultural areas and 12 in nonagricultural areas. Sampling takes places four times annually and the samples are analyzed for general chemical and physical variables. The R3 monitoring programme consists of six small (< 15 $km^2$) agricultural catchment areas selected as being representative of the soil types, climatic conditions and farming practices in Denmark. The objectives are to monitor the impact of farming on the leaching of nutrients to the surface water and upper layers of groundwater. In the catchment, the quality of soil water, drainage water, upper groundwater and river water are assessed. Sampling is generally undertaken at weekly or fortnightly intervals and analyzed for general chemical and physical variables and pesticides. Additionally, land-use practices (crops grown, use of fertilizers, etc.) in the catchments are described annually.

**Lakes**
The objectives of the lake monitoring programme L1 are to record the magnitude of nutrient loading and to elucidate trends in lake nutrient loading and its effects on physical, chemical and biological conditions. Of a total of 468 Danish lakes larger than 5 ha, 37 are included in the monitoring programme. These lakes are studied intensively each year, including sampling and measurement of nutrients in the main tributaries, and 19 annual water samples taken from lake water and analyzed for general chemical and

physical variables, phytoplankton and zooplankton. Additionally, macrophytes, fish and the chemical composition of lake sediment is studied every five years.

**Marine waters**

Monitoring of the marine waters is performed in close cooperation between the counties and NERI. The counties are responsible for monitoring of estuarine and coastal waters. The objectives of the nation-wide coastal and marine monitoring programme M1 are to determine how and to what extent conditions in coastal and marine waters are influenced by nutrient loading and to follow the trends in physical, chemical and biological conditions in marine areas. The sampling programme covering coastal areas includes hydrography, oxygen concentration, nutrients, plankton, zoobenthos and macrophytes. Water samples are generally taken at monthly intervals, however, at 19 intensive sampling sites 32-52 annual samples are taken. The county network includes around 200 coastal and 80 offshore sampling sites.

Water quality of the open sea is monitored during ten annual cruises in the Inner Danish waters (Kattegat, the Belt Sea and the Baltic Sea) and one cruise in the North Sea and the Skagerrak. The sampling programme for the open sea includes hydrography, oxygen concentration, nutrients, plankton and zoobenthos. The heavy metal content of sea water, fish and bivalves is monitored as well. The annual evaluations and reports of the state of the environment are supplemented with data from The Danish Institute for Fisheries and Marine Research, Swedish, German, and Norwegian investigation in the open marine areas.

**Table 3.3:** Danish national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & national reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Nation-wide Monitoring Programme<br>Monitoring of streams | NERI | Chemical and physical variables<br>Macroinvertebrates | Since 1989<br>SF: 12-26 (52)/yr | Nation-wide, 261 sampling sites in approx. 125 river systems | Database: NERI<br>Reporting: NERI |
| R2 | Nation-wide Monitoring Programme<br>Monitoring of springs. | NERI | Chemical and physical variables | Since 1989<br>SF: 4/yr | Nation-wide<br>58 springs | Database: NERI<br>Reporting: NERI |
| R3 | Nation-wide Monitoring Programme<br>Monitoring of agricultural watersheds | NERI | Chemical and physical variables on soil water, drainage water, ground water and river water. | Since 1989<br>SF: 12-26 (52)/yr | 6 agricultural watersheds | Database: NERI & GSD<br>Reporting: NERI & GSD |
| R4 | Inventory of biological assessment of river quality | EPA | Macroinvertebrates<br>Quality classification grades | Since 1989<br>SF: 1-2/yr | Nation-wide.<br>10,000 sampling sites | Database and reporting: EPA |
| **Lakes** | | | | | | |
| L1 | Nation-wide Monitoring Programme<br>Monitoring of lakes | NERI | Chemical and physical variables in lake water and tributaries.<br>Phyto- & zooplankton, fish and macrophytes.<br>Sediment composition | Since 1989<br>SF: Lake water 19/yr<br>Tributaries 12-26/yr<br>Plankton 19/yr<br>Fish, macrophytes & sediment 1/5 yr | Nation-wide<br>37 lakes | Database: NERI<br>Reporting: NERI |
| **Coastal and marine areas** | | | | | | |
| M1 | Nation-wide Monitoring Programme<br>Monitoring of coastal and open marine waters | NERI | Chemical and physical variables.<br>Phyto- & zooplankton, zoobenthos and macrophytes.<br>Sediment composition | Since 1989<br>SF: Water 8-52/yr<br>Plankton 8-52/yr<br>Zoobenthos 1/yr<br>Macrophytes & sediment 1/5/yr | Nation-wide<br>200 coastal sampling sites and 80 offshore sampling sites. | Database: NERI<br>Reporting: NERI |

NERI: National Environmental Research Institute, Ministry of Environment and Energy, GSD: Geological Survey of Denmark, Ministry of Environment and Energy

# Finland

With a total area of 338,145 $km^2$ Finland is bound on the west by the Gulf of Bothnia and south by the Gulf of Finland (Baltic Sea). The Finnish population is about 5.1 million with most of the population being concentrated in the southwest and southern parts of the country.
About 10 per cent of the total surface area of the country is covered by inland surface waters. 74 main water course systems create the basic study units for monitoring of inland waters. The total length of Finnish rivers and streams is about 20,000 km. The five largest river systems drain approximately 56 per cent of the Finnish territory. There are 46 lakes with a surface area exceeding 100 $km^2$ and about 56,000 lakes with an area greater than 0.01 $km^2$. The Finnish coastline is about 39,000 km. The main Finnish marine areas are the Gulf of Bothnia, the Baltic Sea and the Gulf of Finland.

**Inland surface waters**
Finland has a long tradition for national monitoring of surface water and many of the national monitoring programmes have been in operation since the 1960s (Table 3.4)

*Involved institutions*
The leading overall role in the implementation of the national Finnish monitoring programmes belongs to the Ministry of Environment. The plans and proposals for national monitoring programmes are prepared by the Water and Environment Research Institute (WERI), and 13 Water and Environment Districts (WEDs) are responsible for the implementation and operation of the programmes. Samples for water quality monitoring are most frequently taken by WEDs. Local monitoring is carried out by officially supervised laboratories. The obligation of polluters to carry out local monitoring is based on the Water Act. Local monitoring must be approved by the WEDs and covers approximately 4,500 sampling sites in rivers, lakes and coastal waters.

The monitoring of water quality in transboundary rivers is managed by a number of transboundary commissions in cooperation with the National Board of Waters and Environment and the respective WEDs.

*Reporting and data storage*
The WEDs prepare their regional reports at request or include the data in the general reports describing the overall state of the environment. National reports are made at irregular intervals without any predetermined protocol, however, national reporting with an interval ranging from 3 to 5 years has been planned. The organization responsible for updating the centralized database on water quality (VETREK) is the Water and Environment Research Office in WERI.

**Rivers and streams**
Finland has four monitoring programmes focused on rivers and streams (Table 3.4). In the first programme, R1, 68 rivers are sampled four times annually with the objective of detecting water quality changes and time-trends in the most important rivers. The objective of the second programme, R2, is to determine the non-point pollution load from agriculture, silviculture and acid sulphate soils and to obtain information on the effect of climatic change and acid precipitation. Under this programme intensive monitoring is carried out in 15 small drainage basins. The objectives of the R3 programme are to estimate the mass discharge from the Finnish territory to the Baltic. The monitoring is based on monthly sampling downstream the 29 main Finnish river systems discharging into the Baltic.

**Table 3.4:** Finnish national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Water quality at river stre-amflow stations. | NBWE & WERI | 41 physical & chemical variables | Since 1962:<br>SF: 4/yr between March-October | National<br>68 sampling sites | Database; NBWE.<br>1 report/yr; WERI |
| R2 | Transport of suspended & soluble material from land areas | NBWE & WERI | 18-26 physical & chemical variables | Since 1962:<br>SF: 1/wk in spring,<br>2/mon. in autumn | 15 small drainage basins | Database; NBWE. 1 report/yr; WERI |
| R3 | Material input to the Baltic Sea by Finnish rivers | NBWE & WERI | 41 physical & chemical variables | since 1970:<br>SF: min. 12/yr | seacoast: 30 stations<br>Rivers: average flow<br>$> 5 m^3 s^{-1}$ | Database; NBWE<br>1 report/yr; WERI |
| R4 | Monitoring of water quality in the bordering rivers of Finland | The trans-boundary water com-missions, NBWR & WEDs | physical & chemical variables | FI-RU; since 1964,<br>SF; 4-12/yr<br>FI-NO; since 1980<br>SF; 7/yr<br>FI-SE; since 1976<br>SF; 12/yr | FI-RU: 8 sites<br><br>FI-NO: 1 site<br><br>FI-SE: 3 sites | Report of informa-tion; WERI |

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|---|---|---|---|---|---|---|
| **Lakes and reservoirs** | | | | | | |
| L1 | Water quality in lake deeps | NBWE & WERI | 28 physical & chemical variables | since 1962:<br>SF: 3/yr | National<br>71 sampling sites | Database; NBWE<br>1 report/yr; WERI |
| L2 | Biological monitoring of inland waters | NBWE & WERI | biological variables | since 1963:<br>SF: every 3'rd yr | National<br>71 sampling sites | Database; NBWE<br>1 report/yr; WERI |
| L3 | Monitoring of bioaccumulating compounds in fresh waters & environmental specimen bank | NBWE & WERI | heavy metals, organic compounds, pesticides | since 1978:<br>SF: every 2'nd or 3'rd yr | major rivers & lakes | Database; NBWE<br>1 report/yr; WERI |
| L4 | Acidification monitoring of surface waters | NBWE & WERI | 25 physical & chemical variables | since 1987:<br>SF: 1/yr | National, 176 + 200 lakes | Database; NBWE<br>1 report/yr; WERI |
| **Coastal and marine areas** | | | | | | |
| M1 | Monitoring of coastal Finnish waters | WERI, Research Laboratory & WEDs | 24 physical & chemical variables, biological variables, heavy metals, organic compounds, pesticids | since 1964, 1966, 1978 depending on the parameter:<br>SF 1-20/yr depending on the parameter | 12 intensive stations,<br>94 other stations | Database; WERI, FIMR.<br>Report; every 5 yr; HELCOM |
| M2 | Monitoring of open sea waters | FIMR & GFRI | 24 physical & chemical variables, biological variables, heavy metals, pesticides | since 1979:<br>SF; daily to 4/yr depending on parameter | All main deep basins in Gulf of Bothnia, Gulf of Finland & the Baltic proper | Database; FIMR & NBWE<br>Report every 5 yr |

FI: Finland; NO: Norway; SE: Sweden; RU: the Russian Federation.
NBWE: National Board of Waters and the Environment; WERI: Water and Environment Research Institute; FIMR: Finnish Institute of Marine Research; GFRI: Game and Fisheries Research Institute; WEDs: 13 Water and Environment Districts; HELCOM; Helsinki Commission

*Transboundary rivers (R4)*
Finland has an extensive borderline with Russia in the east. Bilateral monitoring of transboundary rivers between Finland and Russia started in 1966. In the beginning, even quite small rivers were included in the water quality monitoring programme. However, since the anthropogenic impact on most rivers is insignificant, today only three rivers and one lake in south-east Finland and four rivers in northern Finland are included in the monitoring programme. In addition, regional cooperation about water quality monitoring is undertaken.

The Finnish borderline with Norway runs along the main Tenojoki River and its tributary the Inarinjoki River, and with Sweden along the main Tornionjoki River and its tributaries. Here bilateral monitoring was initiated in 1964 and in 1976, respectively.

**Lakes**
Finland has four national monitoring programmes mainly focused on lakes. 71 lakes are included in the L1 programme aiming at detecting changes and time-trends in water quality of the most important waterbodies. The L2 programme focuses on the biological state of lakes with the objective of detecting the early changes in water quality by means of biological methods. Sampling of phytoplankton, periphyton, zooplankton and bottom
fauna is undertaken in 71 lakes every three years.

The L3 monitoring programme includes both lakes and rivers and aims at determining the amount of and level trends in toxic substances in the aquatic environment. The objectives of the L4 monitoring programme are to detect long-term changes in the acidification of small head-water lakes as a consequence of atmospheric deposition. The programme consists of two networks: a network including 176 lakes throughout the country in which one annual sample is taken and analyzed for indicators of acidification, and a network including 200 lakes in Lapland in which samples are taken once every 2nd or 3rd year.

**Marine areas**

*Involved institutions*
WERI and WEDs are responsible for national and local monitoring in coastal (Finnish territorial) waters. The coastal water assessment is made at 5 years intervals by the NBWE. The authorities own laboratories and some of the authorized water laboratories carry out the monitoring of the coastal waters.

Monitoring of the open sea is undertaken by the Finnish Institute of Marine Research (FIMR; subordinated to the Ministry of Communications and Traffics) that also has its own database for monitoring and research results. FIMR carries out the Baltic Monitoring Programme (BMP) coordinated by the Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM). The bilateral governmental agreement with Sweden (the Committee on the Gulf of Bothnia) also includes monitoring activities in the Gulf of Bothnia. Corresponding agreements with Russia and Estonia on the Gulf of Finland exist, but the routine cooperation with these countries undergoing a period of transition is still limited.

*Monitoring of coastal waters*
The monitoring of Finnish coastal waters (M1) consists of three parts: physical and chemical monitoring, biological monitoring and monitoring of harmful substances. The objectives of the monitoring are to procure information on the quality and loading of Finnish coastal waters and on the state of biological communities, to study spatial and temporal variations in the environmental state, and to provide background data and follow the levels and changes in harmful substances. The programme includes 12 intensive sampling sites at which as many as 20 annual samples are taken and 94 other sites which are sampled twice a year.

*Monitoring of open sea waters*
The Finnish monitoring programme for the open sea (M2), which is carried out by FIMR, covers the Gulf of Bothnia, the Gulf of Finland and the Baltic proper. The main constitutents of the programme are the Baltic Monitoring Programme (BMP) by HELCOM and secondarily the agreement with Sweden on the monitoring of the Gulf of Bothnia and corresponding agreements with Estonia and Russia.

# France

France covers 543,964 $km^2$ and has a population of 56.7 million (1990). The total river length is around 273,000 km of which the majority are small creeks, only about 35,000 km of the rivers being more than 1 meter wide. The major river systems in France are the Loire, the Rhône, the Seine and the Garonne covering 62 per cent of the French territory. The exact number of lakes is unknown, but the numbers of fresh and brackish waterbodies have been estimated to be 9,800 and 690, respectively. The largest lake is Lac Léman shared with Switzerland. France has coastline along the North Sea, the English Channel, the Atlantic Ocean and the Mediterranean.

**Monitoring of rivers (R1)**

*Involved institutions*
The national surface water network (R1) is based on six basin agencies acting under the general supervision of the Ministry of Environment, each agency managing a national basin network, RNB (Réseau National de Bassin). As a general principle, sampling frequencies, lists of water components to be analyzed, and analytical methods to be used are directly determined by the subsequent users of data.

*Objectives*
The purpose of the RNB is to provide a set of reliable data related to French inland surface waters. RNB does not constitute the total of measured and available data, since many other organizations perform water composition measurements; nevertheless, it aims at being the permanent reference in its field.

*Organization and coordination*
The present organization is the outcome of the legal dispositions enforced by the 1964 Water Act; an overall water quality inventory is to be performed every five years. Since 1972, "permanent sampling points", linking two successive inventories supported jointly by state subsidies and basin agencies, were monitored to provide data. However, this method was expensive and only little information was gathered. In 1987, the system was radically transformed, the result being the RNB. Most of the previous variables (constituents analyzed and environmental data) and sampling sites have been kept.

Presently, RNB is co-ordinated at the state level and operated at basin agency level. State co-ordination involves the following tasks: checking the application (in each basin) of the national rules, specific problems may, however, be addressed differently by the agencies, ensuring laboratory intercalibration and approval; cooperation with AFNOR (the French National Standardisation Body) for periodical improvement of analytical methods and standardization of new methods. Providing data on public requests at national level. For the last purpose, a specific organization, the RNDE (Réseau national des donnés sur éau: National water related network), is being developed.

*Network and variables measured*
The RNB 1994 programme covers 1,082 sampling sites, 946 of which are sampled yearly. The minimum annual sampling frequency permitted for these sites is eight samples per year. At each sampling site general physical and chemical variables such as pH, conductivity, organic pollution indicators, nutrients and specific ions are measured. At selected sites metals and organic micropollutants are measured.

**Lakes**
No French national lake monitoring programme exists.

**Table 3.5:** French national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | **(SF)** | | |
| **Rivers and streams** | | | | | | |
| R1 | Inventory of the quality of running fresh waters | RNB | 47 physical & chemical variables | since 1987<br>SF: min. 8/yr | National<br>1082 sampling sites | Database; RNB<br>Report; RNDE, RNB |
| **Lakes and reservoirs** | | | | | | |
| | No national network exists | | | | | No national data storage |
| **Coastal and marine areas** | | | | | | |
| M1 | National sea water quality monitoring network - RNO | RNO | basic components, enzymatic activity, metals & pesticides | since ?<br>SF: water; 2-12/yr<br>biomass; 4/yr<br>sediment; every 2-5 yr | 43 areas, each composed of several sampling sites | Database; RNO<br>annual reports;<br>IFREMER |
| M2 | French seashore microbio-logical monitoring - REMI | REMI | faecal coliform, salmonellas | | 314 sampling sites in 88 areas | database; REMI/ REPHY<br>Report; IFREMER |
| M3 | French seashore phytoplankton monitoring - REPHY | REPHY | phytoplankton species composition, toxicity | SF: twice a month, alert monitoring on a weekly basis | 37 sampling sites;<br>alert programme 70-80 sites | database; REMI/ REPHY<br>Report; IFREMER |

RNB: National Basin Network; RNO: National sea water quality monitoring network; IFREMER: Institut Francais de Recherche pour l'Exploitation de la Mer; REMI: French seashore microbiological monitoring; REPHY: French seashore phytoplankton monitoring. network.

*Data storage and reporting*

Each basin agency usually stores its own data. Standard reporting is examined by the RNDE. At the end of 1994, systematic reporting will include historic water quality data and detailed data synthesis for each sampling site.

**Coastal and marine area**

Three national networks, managed by IFREMER (Institut Francais de Recherche pour l'Exploitation de la Mer), are devoted to marine waters (M1-M3):

- National sea water quality monitoring network, RNO (Réseau national d'obsevation de la qualité du milieu marin) (M1);
- French seashore microbiological monitoring, REMI (Réseau de surveillance microbiologique du littoral francais) (2);
- French seashore phytoplankton monitoring network, REPHY (Surveillance du phytoplankton du littoral francais) (3).

The objectives of the RNO (M1) is evaluation of the levels and tendencies of the overall variables describing sea water quality. IFREMER co-ordinates sampling and analyses performed by several local organizations. The RNO network consists of 43 sites, each composed of several stations. Sampling frequency varies between 2-12/yr and variables measured include general physical and chemical water quality variables, metals and pesticides.

The objectives of the REMI (M2) are evaluation of the levels and tendencies of microbiological contamination of the sea, mainly focused on shellfish. The programme consists of a survey network of 88 sites and 314 sampling points and an intervention network of 278 points. Faecal coliforms are measured at all sampling sites and Salmonella is measured at intervention sites.

REPHY (M3) is a long-term phytoplankton survey, and monitoring programme that is used during blooms of toxic algae, "red tides", etc. The programme consists of a survey network of 37 sampling sites and an alert network of 70 to 80 sampling sites. Sampling is undertaken twice a month with determination of phytoplankton species and shellfish toxicity assays.

# Germany

Germany has a land area of 356,733 $km^2$ and a population of about 80 million. Inland surface waters are subdivided into six major river systems: ie. the Rhine, the Ems, the Weser and the Elbe draining into the North Sea, the Oder river draining into the Baltic Sea, and the Danube flowing off into the Black Sea. Natural lakes are mainly found in the North German Plain and in the Alpine foreland. They cover a total area of 1,213 $km^2$. There is a total of 26 natural lakes with a surface area of more than 10 $km^2$ each. In the north-west, Germany has a coastline to the North Sea and in the north-east to the Baltic.

**Administrative structure**

Germany is a federation consisting of 16 Länder (or Federal States), each having its own legislation and administration. The Länder are, however, integrated into the Federal Republic as a whole and participate in Federal legislation.

The Federal Government has the right to enact general provisions concerning water resources management. This means that the Federal Government is empowered to specify a general legal framework for the Länder. The Länder then elaborate these general laws by enacting their own laws and supplementary regulations. The Länder are responsible for the administrative enforcement of

all the provisions relating to water including Federal laws and consequently the fulfilment of public functions in water resources management. An exception is the Federal waterways, the development and maintenance of which are exclusively under the control and administration of the Federal Government.

The Federal Ministry of the Environment, Nature Protection and Reactor Safety deals with basic questions of water resources management as well as with transboundary cooperation within the field of water resources management as a part of the environmental policy. The Federal Ministry of the Environment is responsible for provisions concerning water protection of the European Union, the protection of the marine environment and for the river basin commissions of waters crossing national borders. The responsibility for surface water quality monitoring is rests by the Länder.

Water quality monitoring in Germany aims at;
- preventing the potential danger to human health,
- assessing the impact of anthropogenic substances on aquatic ecosystems,
- documenting the present state of water pollution,
- showing the efficiency of water protection measures by means of emission values.

**Monitoring of inland surface waters**

**Rivers**
Each of the 16 Länder has its own inland surface water monitoring programmes. These programmes have Länder specific aims, defined in accordance with common objectives of the Joint Commission of Federal States (LAWA). The common objectives are:
- Long-term trend monitoring
- Monitoring as a tool in planning and management
- Checking up on the fulfilment of water quality demands and the response to utilization
- Monitoring of critical loads (Alarm networks, waterbodies in a critical state)

The surface water quality monitoring programme (1993) for Nordrhein-Westphalen, for instance, consists of four networks (LAWA, 1995):
- a trend network including 90 sampling sites with a sampling frequency of 13 annual samples and measurement of an extensive number of variables (general physical, chemical, biological and microbiological variables, heavy metals, radioactivity determinands and organic micropollutants), some of them also being measured in the sediment or in suspended matter.
- an intensive network including 250 sampling sites with a sampling frequency exceeding 1 annual sample and measurement of a number of variables (general physical and chemical variables, nutrients and specific ions)
- a basic network including 3,500 sampling sites with a sampling frequency of 2 annual samples every five years and measurement of general physical and chemical variables.
- an alarm network including 13 sampling sites with continuous measurements of basic variables and automated measurements of nutrients and organic micropollutants including pesticides.

Also a monitoring programme assessing the biological state of rivers exists. Results from these monitoring programmes are published in annual reports.

At present, national reporting of Länder results is limited. Every five years the LAWA prepares a status report in which the water quality of inland surface waters is classified according to seven categories based on biological variables (R2).

To ensure standard evaluation of flowing waters throughout the Federal Republic of Germany, the quality categories used correspond to the criteria published by the German Industrial Standard (DIN) 38410 (part I+II). The biological classification map is based on local evaluation of the river quality by each Länder after which the map is put out at the national level.

R1, a national monitoring programme covering rivers is also based on the information collected by the Länder with the objective of determining environmental state and trends. The monitoring network consists of 146 sampling sites mainly situated in large rivers. At some sampling sites, variables such as temperature, pH, conductivity and dissolved oxygen are measured continuously, while other variables such as organic pollution indicators, nutrients and heavy metals are measured at fortnightly or monthly intervals. The results of the network are published by the LAWA every 5 years.

*Transboundary waterbodies*
In Germany integrated management of transboundary water courses lies within the framework of international commissions as for entire river basins, and as far as waters forming the border to other countries are concerned management is regulated according to bilateral agreements. Germany is a member of:
- the International Commission for the Protection of the Rhine against Pollution
- the International Commission for the Protection of the Elbe
- the International Commissions for the Protection of the Moselle and the Saar against pollution
- the International Commission for the Protection of Lake Constance

- The Interational Commission for the Protection of the Danube, and has close relations with the neighbouring states regarding waters crossing its frontier. The International Commission for the Protection of the Oder is expected to be signed in 1995.

**Lakes**

A national monitoring programme of the environmental state of lakes does not exists. Monitoring of lakes is done under the authority of the 16 Länder.

**Marine waters**
Monitoring of German coastal waters is undertaken by the individual Länder, while monitoring of open marine waters is undertaken by federal institutes. The activities are coordinated by the ARGE Bund/Länder Messprogramm.

The aim of the marine monitoring programmes is to evaluate:
- possible health risk from contaminated fish, mussels and shrimps
- the effect of antrophogenic substances on the ecosystem (effect monitoring)
- long-term effect of emission reduction (trend monitoring).

*The North Sea*
At the national level, data collection aimed at assessing the environmental condition of the North Sea is undertaken according to the Bund/Länder Messprogramm (M1) and at the international level according to the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions (OSPARCOM). At sampling sites in estuarine and coastal areas as well as open marine waters measurement of general chemical and physical variables plus organic micropollutants and heavy metals in water, sediment and biota are carried out.

**Table 3.6:** German national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Überwachungsprogramm der Länderarbeitsgemeinschaft Wasser (LAWA) | FS, LAWA (UB for data collection) | Physical & chemical variables. | Since 1982<br>SF: 13/yr | Nation-wide<br>146 sampling sites | Database:<br>QUADAWA(UB)<br>Report every 5 yrs:LAWA |
| R2 | Biological classification of the quality of inland surface waters (rivers) | LAWA | Biological:<br>INVERT<br>Saprob.index | Since 1975<br>SF: once within 5 yrs | Nation-wide | Database: no national database<br>Report every 5 yrs:LAWA |
| **Coastal and marine areas** | | | | | | |
| M1 | Bund/Länder-Messpro-gramm für die Nordsee | ARGE | Physical, chemical and biological variables | Since 1980<br>SF: 1-4/yr | 53 sampling sites in the North Sea | Database:<br>MUDAB<br>Report: ARGE |
| M2 | Bund/Länder-Messpro-gramm für die Ostsee | ARGE | Physical, chemical and biological variables | SF: 5-11/yr | Baltic Sea and Baltic Proper | Database: MUDAB<br>Report: IOW |

FS: Federal States (Länder); LAWA: Joint Water Commission of the Federal States ('Länderarbeitsgemeinschaft Wasser'); UB: Umweltbundesamt; ARGE: Bund/Länder-Messprogram Committee, Federal Ministry of the Environment; MUDAB: Marine data base (Meeresumwelt Datenbank); QUADAWA: River Water Database ('Qualitätsdatenbank Wasser'); IOW: Institut für Ostseeforschung, Warnemünde.

*The Baltic Sea*
Monitoring of the Baltic is done on national level according to the Bund/Länder Messprogramm (M2) and internationally according to the Baltic Monitoring Programme (BMP) of the Helsinki Commission (HELCOM). A number of sites in estuarine and coastal areas are sampled up to 11 times a year with measurements of physical, chemical and biological variables, including organic micropollutants and heavy metals.
A number of off-shore sites are sampled 5 times a year, measuring physical, chemical and biological determinands.

# Greece

Greece has a land area of 131,944 km$^2$ and a population of 10,3 million (1991) of which about 90% live along the Mediterranean coastline. Greece consits of the northern peninsula and about 3,000 islands in the Aegean, Ionian and Cretian Seas. The major river systems of Greece are located in the northern part of the country and generally run from north to south. The largest rivers are the Axios, the Aliakmonas, the Achelos, the Pinios, the Evros, and the Strymonas. The major lake areas are located in the western part of Greece, 14 lakes having a surface area exceeding 8 km$^2$. Greece is surrounded by the Ionian Sea to the west, and the Aegean Sea to the east, both having a jagged coastline and many gulfs. The coastline of Greece is 15,000 km, which is one third of the total Mediterranean coast.

**Monitoring of surface waters**
The Water Section (WS) within the Environmental Planning Section of the Ministry of the Environment is the general coordinator of all monitoring activities on surface water quality.

**Inland surface waters**

Two national monitoring programmes focus on inland surface waters: one programme (R1) has been in operation since the early 1980s and is performed by the Laboratory of Soil-hydrology and Geology (L.S.G.) of the Ministry of Agriculture, and a second programme (R2) is currently being established with the six General Chemical State Laboratories (G.C.S.L.) being the responsible institutions.

The objectives of the R1 programme are to determine the level of pollution and the chemical composition of surface water used in agriculture. Analysis of general chemical and physical variables and heavy metals is performed on monthly water samples taken in rivers and lakes all over Greece (approximately 250 sampling sites, primarily in the six largest river systems). The data collected by L.S.G. are reported to the Water Section.

The six laboratories in charge of the R2 programme monitor physico-chemical and microbiological variables in surface and coastal waters of their districts (Prefectures) within the framework of national monitoring networks and in accordance to EU directives. These laboratories take the samples, carry out the analyses and report the information to the Ministry of the Environment. The monitoring programme was initiated in 1993 and is not in normal operation yet.

*Transboundary surface waters*
The rivers Axios, Strymonas, Nestos and Evros are located in northern Greece and originate from former Yugoslavia and Bulgaria. The monitoring of their water quality is accomplished by automatic sampling stations located at the points of their entrance to the Greek territory. The continuously monitored variables (pH, temperature, conductivity, dissolved oxygen, turbidity and water level) are registered automatically in databases and teletransmitted to the competent prefecture as well as to the Ministry of the Environment in Athens. Furthermore, alarm signals are also teletransmitted when the variables exceed the limit values. The stations also have at their disposal a pre-programmed automatic sampler for taking samples to be further analyzed in the laboratory.
The lakes Megali Prespa and Mikri Prespa are located at the boundaries of Greece and Albania and former Yugoslavia, respectively. They are protected by the RAMSAR convention. Also the Doirani is situated near the Greek-Former Yugoslavian border. The above-mentioned lakes are monitored within the framework of the National Monitoring Programme for Surface Waters (R2).

**Marine waters**
The National Monitoring Programme for Surface Waters (R2) also includes monitoring of coastal waters.
The National Centre for Marine Research (N.C.M.R.) has participated in the Mediterranean Pollution Monitoring and Research Programme (MED POL/UNEP) since 1976, both including the monitoring of coastal waters and in related research activities. Currently, it carries out an extensive programme of monitoring pollution variables in the Aegean and the Ionian Sea and the Saronic Gulf (M1). This programme has been in operation since 1985 with approximately 4 samples per year and includes measurement of general water quality variables and heavy metals in biota.

The Institute of Marine Biology of Crete (I.M.B.C.) is in charge of comprehensive research and development programmes and for national and regional programmes on the marine environment covering the littoral as well as the deep sea, according to which the physical and chemical variables and the impact on living organisms are examined. The M2 monitoring programme is a part of the MED POL monitoring covering the Cretian waters and has been in operation since 1988 with approximately 3 annual samples.

**Table 3.7:** Greek national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Inland surface waters** | | | | | | |
| R1 | Monitoring of surface water quality | L.S.G. | organic & inorganic chemical variables physical variables | since early 1980s SF: monthly & seasonally | Greek surface waters | Database; L.S.G. annual reports, WS |
| R2 | National Monitoring Programme for Surface Waters | G.C.S.L. | physico-chemical variables | not in operation yet | surface waters of the corresponding district | Database; G.C.S.L. annual reports, WS |
| **Coastal and marine areas** | | | | | | |
| M1 | MED POL in the Aegean and Ionian Sea MED POL in the Saronic Gulf | N.C.M.R. | organic & inorganic chemical variables, biological & physical variables | since 1985: SF: seasonally, 4/yr | Saronic Gulf, Aegean & Ionian Sea | Database; N.C.M.R. biannual reports; WS |
| M2 | MED POL, Cretian marine waters | I.M.B.C. | organic & inorganic chemical variables | since 1988: SF:seasonally, 3/yr | Cretian marine waters | Database; I.M.B.C. biannual reports;WS |
| M3 | Bathing waters Determination of possible | WS | biological variables | since 1988: SF: fortnightly | Greek bathing areas | Database & annual reports; WS |

| | | | | | | |
|---|---|---|---|---|---|---|
| | pollution problems | | | (May-October) | | reports; WS |

WS: Water Section, Ministry of Environment; L.S.G.: Laboratory of Soil-hydrology and Geology, Ministry of Agriculture;
G.C.S.L.: General Chemical State Laboratory; I.M.B.C.: Institute of Marine Biology of Crete; N.C.M.R.: National Centre for Marine Research

# Iceland

Iceland is an island located on the mid-Atlantic ridge in the northern part of the Atlantic Ocean. The population is 266,000. The country area is 103,000 $km^2$ with a coastline of 4,790 km. It is a mountainous country, the average altitude being 500 m above sea level. The central highlands are surrounded by lowlands cut by fjords and valleys. Continuous vegetation covers about 25% of the land area, glaciers constitute about 11%, and lakes and rivers cover 2.2% or 2,300$km^2$. The remaining 60,000 $km^2$ are sparsely vegetated or consist of barren land. Iceland has 1,840 lakes with a surface area greater than 0.1 $km^2$, most of them being, however, small. The rivers are short and fast-flowing.

**Monitoring of surface water**
No national monitoring network is currently in operation, but programmes for monitoring of rivers, lakes and marine areas are presently being established. The organization responsible is the Environmental and Food Agency.

**Rivers and streams**
In the period 1971-74 a survey on the chemical composition of river water was carried out in 20 rivers in western Iceland. Currently flow is measured systematically and temperature and conductivity regularly at 112 sampling sites around the country. The turbidity is measured in glacial rivers. The National Energy Authority are responsible for these measurements. A nation-wide monitoring programme under the Ministry for the Environment is yet to be established. The objective is assessment of nutrient loading of rivers and streams.

**Lakes**
Two lakes, Lake Thingvallavatn and Lake Mývatn, have been subject to intensive studies. Lake Mývatn and its affluent, the river Laxa, are monitored every year, principally by means of biological monitoring, while chemical measurements in the tributaries, the affluents (river Laxa), and in the lake itself are made on a more irregular basis. The Lake Mývatn monitoring programme, as well as separate research projects, are undertaken under the auspices of the Ministry for the Environment, the University of Iceland and the Lake Mývatn Research Centre.

**Marine waters**
Marine monitoring programmes focusing on pollutants in the ocean are being developed in accordance with the international programmes and agreements in which Iceland participates. Iceland joined the Arctic Monitoring and Assessment Programme (AMAP) in 1991 and also puts great emphasis on taking part in the Joint Monitoring Programme (JMP).

A working group under the Ministry for the Environment is responsible for establishing and implementing the monitoring programmes. The institutes involved are: the Marine Research Institute, the Icelandic Meteorological Office, the Department of Pharmacology of the University of Iceland, the Directorate of Shipping and the Environmental and Food Agency.

# Ireland

The Republic of Ireland has a land area of about 70,000 $km^2$. At the time of the 1991 census the population was 3.5 million and population density accordingly just exceed 50 inhabitants per $km^2$. There are some 75 rivers, including important tributaries, with catchment areas above 130 $km^2$, and there are a further 167 minor rivers and streams whose catchments vary in size from just under 130 $km^2$ to 10 $km^2$. In all, more than 13,000 km of major river channels and tributaries can be found as depicted on the Ordnance Survey Catchment Map. The Shannon is the largest river with a catchment area of 11,800 $km^2$. The second largest river system is that of the Barrow, the Nore, and the Suir rivers. The Shannon and the Barrow-Nore-Suir river systems together drain over one third of the area of the country. The Irish lake database lists over 4,000 lakes and ponds and their combined total area is approximately 2 per cent of the total country area. In Ireland there are some 58 lakes with a surface area greater than 1 $km^2$. The Irish coastline is deeply indented, particularly in the west, and its length, including estuaries, is 5,630 km. Estuarine and coastal areas are significant receiving waters in that over 80 per cent of the estimated waste loads from urban sewage and from industry enter tidal waters. The ten largest cities and towns in Ireland are situated adjacent estuaries or the coast. There are 18 estuaries, or combinations of estuaries, with contributing catchment areas of more than 500 $km^2$.

**Involved institutions and coordination of monitoring**
The Minister for the Environment has the overall responsibility for the development and implementation of environmental policy in Ireland. The Department of the Environment formulates the relevant legislative framework to maintain satisfactory regulatory and monitoring systems for environmental protection and to secure the provision of infrastructural services necessary for both environmental and developmental purposes. The responsibilities of the Department regarding environmental information are the result of policy needs, statutory requirements and international obligations. In general, the responsibility for implementing the monitoring of the ambient environment rests with the local authorities, ie. the county councils and the county borough councils of which there are thirty-four in all. The local authorities operate under the aegis of the Department of the Environment.

*Environmental Protection Agency*

Since the early 1970s An Foras Forbartha (AFF) was in charge of advisory and support services to the Department of the Environment and local authorities, a role that from 1988 has been taken over by the Environmental Research Unit (ERU). In July 1993, these organizations were abolished and their environmental staff and facilities were transferred to the newly established Environmental Protection Agency (EPA). In addition to its advisory and supporting role, the EPA has wide powers within the area of environmental protection. The EPA is an independent agency that was set up according to the Environmental Protection Agency Act of 1992. Its wide range of functions includes an overall co-ordination and supervisory role relating to environmental monitoring, including the monitoring of surface waters. In particular, the Agency is required to prepare a national monitoring programme and to identify the organizations to undertake its implementation. The setting-up of the EPA has not altered the fact that the primary responsibility for the monitoring of the ambient environment rests with the local authorities. However, the majority of the national river monitoring programme is undertaken by the EPA on behalf of the local authorities.

The drafting of the national monitoring programme is well-advanced at the time of writing. When the draft has been prepared, consultations will have to take place. Not until this process is completed will the programme be finally adopted. Aspects of the former monitoring programme are, however, carried on and the description presented here therefore reflects this phase of transition.

Three of the EPA's Regional Inspectorates, namely the laboratories in Kilkenny, Monaghan and Castlebar, implement monitoring programmes on the quality of surface waters on behalf of groups of local authorities in the south-east, north-east and western Ireland, respectively. The EPA has been undertaking a programme of laboratory intercalibration for quality assurance purposes. The EPA Regional Inspectorate, Dun Laoghaire, undertakes more specialised investigations at the national level, on eg. riverine inputs to tidal waters, acidification, etc. The EPA is also required to develop an environmental data storage system. A recent study has given the EPA the central role in the proposed development of an Irish integrated environmental information system. This is consistent also with its role as National Focal Point for the European Environment Agency.

*Department of the Marine / Marine Institute*
The Department of the Marine implements a monitoring programme mainly through the work of its Fisheries Research Centre and this role will devolve to the recently established Marine Institute. The monitoring programmes have been carried out with the following objectives: (1) ensuring the quality of fish for human consumption; (2) identifying sources of pollution; (3) determining temporal trends and spatial distribution of contaminants in offshore, coastal and estuarine environments. An important aim of the programmes is to comply with various international agreements. Quality assurance activities include participation in the EU-funded QUASIMEME quality control programme.

*Radiological Protection Institute of Ireland*
The Radiological Protection Institute of Ireland is a national organization having regulatory, monitoring and advisory responsibilities in matters pertaining to ionising radiation. The Institute monitors radioactive contamination in the environment, on land, sea, and in the air. The environmental monitoring programme includes measurement of natural and artificial radionuclides in, for example, fish, shellfish, coastline and deep sea sediments, seawater and seaweeds.

**National monitoring activities**
*Rivers*
The physico-chemical quality of rivers is monitored by the local authorities or by EPA Regional Inspectorates on behalf of the local authorities. The R1 national monitoring programme (Table 3.8) includes mainly large rivers and their main tributaries with approximately 1,500 sampling sites in 300 rivers. The aim is to obtain a sampling frequency of 12 times annually, the water samples being analyzed for indicators of organic pollution, nutrients and, as regards some, metals. The biological quality of rivers is monitored according to a national programme operated by the EPA (R2). The biological quality of rivers has been assessed every three to five years since 1971. The R3 monitoring activity is an annual recording of fish kills aimed at assessing their causes.

**Table 3.8:** Irish national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & national reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Physico-chemical Surveys of River Water Quality | EPA<br>Local Authorities | Water: Physical and chemical variables at some sampling sites measurements of metals | Since 1970-71<br>SF: varying (12/yr) | Nation-wide. Mainly large rivers and primary tributaries | Database: EPA & local authorities.<br>Reporting: every three years by EPA |
| R2 | National Biological Survey of River Water Quality. | EPA | Water: TEMPW, OX<br>Biological: INVERT, MAPHYT, Filamentous algae, Siltation | Since 1971<br>Every 3rd year or more frequently | Nation-wide. 3000 sampling sites in 1200 rivers and streams | Database: EPA<br>Reporting: Every 3rd year by EPA |
| R3 | The Recording of Fish Kills | DoM | Fish kills and if possible, their causes | 1971-1974 and 1983 to date | Nation-wide.<br>No specific network | Reporting annually by DoM |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Lakes** | | | | | | |
| L1 | Lake Water Quality Monitoring Programme.<br>(a)In situ measurements.<br>(b)Remote sensing surveys | EPA & Local Authorities, RPII, CFB | (a) Water: Chemical & physical variables<br>(b) Remote sensing | (a)Since the late 1960s SF: from several times per year to 1/3-5yr<br>(b) 1989-1990 | (a) Nation-wide. Large lakes and representative smaller lakes. 170 lakes.<br>(b) Nation-wide. 360 lakes | Data and reporting: EPA & local authorities. Every three years |
| **Coastal and marine areas** | | | | | | |
| M1 | General Quality of Estuarine and Coastal Receiving Waters Including Nutrients. | FRC, EPA, DoM & Local authorities | Water: Physical and chemical variables | Since 1992.<br>1 winter survey and a number of surveys in summer | Nation-wide. Significant estuaries & coastal areas and the Western Irish Sea | Reporting: 1/4 yr by EPA, DoM & local Authorities |
| M2 | Metals and organic micropollutants in the Estuarine and Coastal Environment. | EPA, FRC/DoM (MI), Local Authorities | Water: organic micropollutants<br>Sediment & biota: heavy metals & organic micropollutants | Since 1993<br>One major estuary per year in a 5-6 year cycle. Trend monitoring of metals in mussels | Nation-wide | Reporting by FRC to the JMG |
| M3 | Radioactivity Monitoring of the Irish Marine Environment. | RPII | Radionucleides in water, sediment, & biota | Since the early 1970s. SF: 2-4/yr. | Nation-wide. Greatest density of sites where the impact of the Sellafield facility is greatest. | Reporting: 1/2yr by RPII |
| M4 | Environmental Quality of Amenity and Recreation Areas, in particular, Bathing Waters | DoE<br>Local Authorities | Water: Physical, chemical, & microbiological variables | Since 1979<br>SF: 1/1-2 week from mid-May to ultimo August | Nation-wide. A total of 92 important marine bathing areas | National reporting annually by DoE |
| M5 | Bacteriological Quality of Shellfish Waters. | DoM | Faecal coli in water and shellfish. | Since 1981<br>SF: 2 weeks intervals throughout the year | Mainly W and SW coast. 200 locations in 50 coastal inlets | DoM |
| M6 | Monitoring of Human Food Sources. | DoM/MI, (FRC) | Water: Physical variables<br>Shellfish: metals & organic micropollutants<br>Fish: HG | Since 1992<br>SF: Annually | Nation-wide.<br>18 shellfish growing waters and 5 important fishing ports | FRC, JMG |

EPA: Environmental Protection Agency; DoM: Department of the Marine; RPII: Radiological Protection Institute of Ireland; MI: Marine Institute; FRC: Fisheries Research Centre; JMG: Joint Monitoring Group; DoE: Department of the Environment; CFB: Central Fisheries Board.

*Lakes and reservoirs*

A national lake monitoring programme is being developed at the present time by the EPA in a situation where there has been only a limited monitoring programme up to this. The EPA is continuing the development of a monitoring programme for lakes using aircraft-borne remote sensing. In-situ monitoring of selected lakes and reservoirs is undertaken by local authorities, by the EPA on their behalf, and by the Central Fisheries Board.

*Estuarine and marine areas*

Estuarine and marine areas are monitored by local authorities, by the EPA on behalf of local authorities, by the Department of the Marine (DoM)/Marine Institute, and by the Radiological Protection Institute of Ireland. The M1 national marine monitoring programme is a combination of the EPA and DoM programmes. The EPA programme aims at working out a general assessment of the quality of Irish estuarine and coastal waters, while the DoM programme concentrates on the Irish Sea. M1 is in particular focused on the impact of organic waste and nutrients. The M2 monitoring programme focuses on toxic contaminants (heavy metals and organic micropollutants) in the Irish estuarine and coastal environments. The M3 programme concerns monitoring of radioactivity in the Irish marine environment. The M4 monitoring programme focuses on bathing water quality, while M5 and M6 assess the quality of seafood used for human consumption. Furthermore, marine biological monitoring is undertaken by the FRC/DoM in a number of separate programmes of varying intensity and duration. These programmes includes assessment of phytoplankton and zoobenthos in association with a number of physical/chemical variables, often heavy metals and organic micropollutants.

# Luxembourg

Luxembourg has a land area of 2,590 $km^2$ and a population of about 390,000 inhabitants (1992). The main rivers in Luxembourg are the Moselle, the Sûre and the Alzette.

The Administration of the Environment is responsible for chemical surface water monitoring. The Hunting and Fishing Department is dealing with the biological inventory of running and standing waters as well as with fishery and police control. The Department collaborates with the Department of Hydraulic Management of the Technical Service of Agriculture and of the Ponts et Chaussées.

Luxembourg has reported on two river monitoring programme (R1 and R2) and one lake monitoring programme (L1). The R1 programme is a general physical-chemical assessment programme covering the main rivers of the country, totally 217 sampling sites. The sampling frequency is 1-13 times a year. The R2 programme has been operating since 1972 and is based on biological assessment of river quality (macroinvertebrates, fish and, occasionally, plankton and macrophytes). Samples are taken in the main rivers and their principal affluents, especially those with fishery interests. Sampling frequency depends on the weight of the pollution; heavily polluted rivers are controlled nearly every year, while waters with a fairly good quality are controlled every 3 to 5 years. Surface waters are classified according to the Belgian Biotic Index. The L1 lake monitoring programme covers 10 sampling sites in 3 lakes. Twentysix physical, chemical and microbiological variables are measured with a frequency of 8 times a year.

**Table 3.9:** National surface water monitoring programmes of Luxembourg.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Biochemical monitoring programme of rivers | AE | 26 chemical and physical variables | SF: 1-13/yr | Nation-wide<br>217 sampling in all main rivers | |
| R2 | Biological management and control of inland waters | AEF, SCP | PHYTPL, ZOOPL, INVERT, MAPHYT, FISH | Since 1972<br>Heavily polluted: 1/year<br>Others: every 3-5 years | Main rivers and principal affluents of the whole country | Reporting: SCP |
| **Lakes** | | | | | | |
| L1 | National Lake Monitoring Programme | | 22 chemical, physical and microbiological variables | SF: 8/yr | 10 sampling sites in 3 lakes | |

AE: Administration de l'Environnement; AEF: Administration des Eaux et Forêts; SCP: Service Chasse et Pêche

# The Netherlands

The area of the Netherlands is about 42,000 $km^2$ including 3,000 $km^2$ large freshwater reservoirs (eg. the IJsselmeer). The Netherlands is a densely populated country with 15 million inhabitants. The main river systems of The Netherlands are those of the river Rhine and the river Meuse. The Rhine has a large impact on The Dutch water management, as approximately two thirds of the water influx is delivered by the Rhine. The main transboundary rivers, the Rhine, the Meuse, and the Scheldt, contribute substantially to the water quality in Dutch surface waters and in the North Sea.

**Involved institutions**
In the Netherlands the Ministry of Transport and Public Works has the responsibility for the national surface waters. Water management is delegated to the operational organization of the Ministry, the Rijkswaterstaat, daily management of surface water being undertaken by operational regional directorates. Expert knowledge and know-how about water quality issues is available at the expert institutes RIZA (Institute for Inland Water Management and Waste Water Treatment) and RIKZ (Institute for Coast and Sea).

RIZA and RIKZ are to: (1) give advice on policy and management; (2) gather information at the national level; surface water quality is monitored, partially analyzed at the RIZA laboratories, and the data is stored in information systems and used in reports on water quality trends and for policy development; (3) coordinate water quality issues at a local level of government, through the CUWVO-coordination commission.

Organizationally Dutch surface waters are divided into national surface waters, for which RIZA and RIKZ are responsible, and regional waters, for which several local waterboards are responsible. National surface waters are the main water (transport) system and include the rivers Rhine and Meuse (including sub-systems), Lake IJssel, estuaries, the Wadden Sea and the North Sea. All other surface waters are part of the regional water systems.

**Inland surface waters**
The monitoring activities of inland surface waters are coordinated by RIZA (Table 3.10).

*National Surface Water Monitoring Programme (R1)*
The major part of Dutch monitoring is encompassed by the yearly **MWTL** (National Surface Water Monitoring Program). The goal of this network, consisting of a physical, chemical and biological part, is to test and detect trends in water quality.

In 1955 chemical monitoring of inland waters was initiated at 4 locations. During the 1970s the number of locations increased by 100 per cent, during the 1980s, however, the number of locations decreased to about 130. In 1992 the monitoring network was evaluated and as a consequence of statistical relations between locations the number of locations was reduced to 26 and frequency increased. In addition to this re-design of the chemical monitoring, the biological monitoring network was started in 1992.

The chemical monitoring network consists of 26 sampling sites in inland waters. Approximately 120 variables are measured and the water concentration of some is analyzed. Since (apolar) organic micropollutants and metals are partially attached to suspended matter, some of these variables are (also) measured in suspended solids.

The biological monitoring network in inland waters consists of the following groups: fish, birds, macroinvertebrates, zooplankton, phytoplankton, vegetation (water plants), and ecotoxicological variables. Some of the variables are measured yearly, as for other variables a four year monitoring cycle is set up according to which each year a water system is subject to detailed study.

*Aqualarm (R2)*
The purpose of the Aqualarm monitoring network is early warning. Based on information on calamities, action can be taken and users of water warned. This network was initiated in 1974 and in the beginning of the 1990s (semi)continuous measurement of water quality was made at 7 on-line stations along the Rhine and the Meuse rivers. Since 1994 three stations remain (at the borders to Germany and Belgium along the rivers the Rhine and the Meuse and at Keizersveer). The instruments used are automated and work continuously in order not to miss incidents during night-time and weekends. Since the start of the network when only the classic variables (dissolved oxygen, temperature, conductivity, turbidity, pH) were measured and ionselective electrodes (for chloride, fluoride and cyanide) were used the number of measured variables have increased along with the introduction of instrumentation for on-line metal measurement (polarographic measurement of Cd, Cu, Pb, Zn), instrumentation for measurement of organic micropollutants and bioalarm systems. At present instrumentation for apolar organic variables (based on preconcentration, GC-FID), volatile organic variables (purge-and-trap GC-FID) and polar organic variables (based on preconcentration, LC-DAD) is installed. Bioalarm systems based on fish and daphnia systems are used and algal and a bacterial systems are planned to be introduced in the future.

*Survey of harmful substances*
In the preparation of the last policy documents RIZA and RIKZ selected the lists of variables to be measured on the basis of toxicity, production and transport information. Since information on the occurrence of many of the harmful (organic) micropollutants is insufficient, the list of variables is divided into a M-(Monitoring)-list and an I-(Inventory)-list. For M-list variables regular monitoring is obligatory, but studies, surveys and analytical methods will have to be developed for I-list variables. The intention is to evaluate the I-list variables before initiating regular monitoring. So monitoring as well as assessment are incorporated into the policy document.

Assessment of the water quality is part of the policy documents and a survey study is undertaken. This study, called **I-list-investigation**, was started in 1991 and will be evaluated in 1995. It concentrates especially on the measurement of new organic micropollutants, such as pesticides, and rare heavy metals at selected locations.

At a national level **polluted sediments** constitute a major problem. For this reason (locally gathered) data on sediment pollution are reported by the CUWVO-coordination to RIZA and stored in an information system. On the basis of this information detailed studies are carried out, policy plans suggested and a clean up is initiated.

**Table 3.10:** Dutch national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Inland surface waters** | | | | | | |
| R1 | National Surface Water Monitoring Programme (MWTL)<br>Monitoring of Inland Waters | RIZA | 120 chemical, physical and biological variables | Since 1955<br>SF: Chemical & physical variables 6-52/yr, biological variables 1-13/yr | Presently 26 sites throughout the country | Data storage and yearly reporting by RIZA |
| R2 | Aqualarm<br>Early warning network | RIZA | Chemical & physical variables | Since 1974<br>(semi-) continuous | 7 online stations along the rivers Rhine & Meuse | No reporting |
| **Coastal and marine areas** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| M1 | National Surface Water Monitoring Programme (MWTL)<br>Monitoring of Marine Waters | RIKZ | Chemical, physical and biological variables | Since 1972<br>SF: chemical & physical variables 1-13/yr, biological variables 1-18/yr | 95 sites along the coast | Data storage and yearly reporting by RIKZ |

RIZA: Institute for Inland Water Management and Waste Water Treatment; RIKZ: Institute for Coast and Sea

**Marine waters**
The monitoring activities in marine waters are coordinated by RIKZ (Table 3.10).

*National Surface Water Monitoring Programme (M1)*
The chemical monitoring programme of marine waters was started in 1972. The present monitoring network consists of approximately 95 locations, of which 21 are used for assessment of bathing water quality, and six for assessment of organic combinations in yacht havens. Sampling frequency varies from once to 13 times annually. The following variables are measured: general variables (oxygen, acidity, BOD, visibility), nutrients and eutrophication variables, inorganic and organic micropollutants, radioactivity variables, bacteriological variables and several sum variables.

*Joint Monitoring Programme*
Under the authority of the Oslo and Paris Commissions the condition of the seas covered by the Convention is being continuously reviewed. For this purpose a Joint Monitoring Programme (JMP) has been in operation since 1979. For the Netherlands the programme comprises (a) estimation of the level of pollutants in edible fish, (b) biological and biological effect monitoring, (c) assessment of spatial distribution of pollution, and (d) assessment of temporal trends in pollution within the Convention Area. The Dutch part of the JMP is closely related to the national programme (M1). Every year the results of the JMP monitoring activities of the preceding year are supplied to the ICES data bank.

**Local monitoring**
The monitoring network of local waterboards operates at a regional level and is therefore not incorporated into the national programme. The regional monitoring network covers several thousands of locations. Network design and operation is coordinated by the CUWVO-commission (RIZA being the coordinator). To make an annual report on Dutch water quality, a nation-wide inventory on water quality data of representative locations has been set up by CUWVO. For the next policy cycle this information will be incorporated into the policy information system called Aquatic Outlook. With this information it is possible to calculate and predict the results of different policy scenarios.

# Norway

Norway has a land area of 324,000 $km^2$ and a population of 4.3 million (1993). The surface waters are an important part of the Norwegian landscape. Most of the largest rivers and catchment areas are situated in the south-east of the country, but there are lot of small rivers along the coast. The four largest Norwegian river systems are covering about a quarter of the Norwegian territory. Norway has a total of 455,000 lakes, the lakes covering an area that is about 5 per cent of the land area. Six Norwegian lakes have a surface area greater than 100 $km^2$. The Norwegian coast is about 2,650 km long; including the vast number of fjords, bays, and islands the total coastline is almost 34,000 km long. Some of the fjords are very long (>100 km) and deep. The main ocean areas are the North Sea, the Norwegian Sea and the Barents Sea

**Involved institutions and coordination of monitoring**
The Ministry of Environment is responsible for reporting state and trends of environmental problems in Norway to the Parliament. The Norwegian Pollution Control Authority (SFT) and Directorate for Nature Management (DN) are two directorates under the Ministry of Environment. SFT is responsible for the National Pollution Monitoring Programme, the main part of which concerns monitoring of freshwater and the marine environment. In addition to the monitoring activities mentioned above, DN is managing monitoring activities concerning nature management, including monitoring of the aquatic environment.

SFT's most important consultant regarding water quality monitoring is the Norwegian Institute for Water Research (NIVA). The consultants are responsible for taking the samples, making the analyses and storing the data. NIVA is reporting the data and information from separate programmes to SFT. SFT and DN report in turn aggregated data to the Ministry of Environment and to the public.

Monitoring of water quality at national and county levels is coordinated. In transboundary rivers between Norway and Finland, Russia, and Sweden, respectively, the water quality monitoring is to some extent coordinated.

*Quality assurance and standards*
In international programmes (PARCOM, ECE, etc.) standards and manuals agreed upon are followed. SFT in general demands that all consultants must be accredited according to EN 45000 standards for sampling and analysis.

Norway has reported information on 10 river monitoring programmes, six lake monitoring programmes, three inland water monitoring programmes and eight monitoring programmes focused at coastal and marine areas (Table 3.11).

**Rivers and streams**

The Norwegian river monitoring programmes can be described by their main purposes and their network of sampling sites. The objectives of the R1 programme is to monitor the riverine inputs into Norwegian coastal waters. The network consists of sampling sites downstream the 10 largest Norwegian rivers, in general including monthly sampling of suspended matter, nutrients and heavy metals. The R2, R8, R13, L4/R9 and L8/R11 monitoring programmes focus on acidification of rivers and streams and the programmes R10 and L9/R12 consider the effects of liming in response to acidification. The R2 programme is to provide long-term data revealing trends in acidification, and the network is based on sampling sites in 20 rivers in southern Norway. The R8 programme consists of intensive studies in five small river catchments. The L4/R9 programme determine the status of acidification and heavy metal pollution in the Norwegian-Russian border area. The R13 programme employs macroinvertebrate indicator species in assessment of acidification effects and L8/R11 monitors the response to acidification at the fish communities level.

The R3-R7 river monitoring programmes focus on monitoring of specific river systems and the major environmental state related to these systems (eg. pollution from paper industry in the river Otra, nutrients and organic carbon in the largest Norwegian river the Glomma, heavy metals from mining in the river Gaula and the river Orkla).

**Table 3.11:** National surface water monitoring programmes in Norway.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Long-term monitoring of direct & riverine inputs to Norwegian coastal waters | NIVA | chemical variables | since 1990<br>SF: 1/month, 8 rivers<br>4/yr, 2 rivers | one station in 10 rivers | Database & annual report; NIVA |
| R2 | Monitoring of 20 rivers in East, South & Western Norway | NIVA | physical & chemical variables | since 1980<br>SF: weekly-monthly | 20 rivers | Database & annual report; NIVA |
| R3-R6 | Monitoring of<br>3. River Otra<br>4. River Glomma, Hedmark<br>5. River Gaula<br>6. River Orkla | NIVA | 3,5, & 6: chemical & biological variables<br>4: water chemistry | 3: since 1980, SF: monthly;<br>4: since 1978, SF: 2/month;<br>5: since 1986, SF: 1-2/month;<br>6: since 1980 SF: 1/month | 3: 6 sites in main river<br>4: 3 sites in main river<br>5: 6 sites in main river, 6 sites in tributaries,<br>6: 2 sites in main river, 2 sites in tributaries | Database & annual report; NIVA |
| R7 | Periphyton studies in the catchment area | NIVA | periphyton | since 1986<br>SF: 2-3/yr | 4 main & 3 additional stations | Local database. Annual report; NVE, SFT, DN |
| R8 | Transport & dynamics of acid compounds in calibrated catchments | NIVA | physical & chemical variables, precipitation | since 1973<br>SF: weekly | National<br>5 calibrated catchments | Database & annual report; NIVA |
| R 13 | Monitoring of invertebrates in Norway | LFI | INVERT, species list, acidification index | since 1981<br>SF: 2/yr | 15-20 stations in 8 river systems | Database & annual report: LFI |
| **Lakes and reservoirs** | | | | | | |
| L1 | National survey on eutrophication in 355 Norwegian lakes | NIVA | chemical & biological variables | 1988-1998<br>SF: 4/yr May-Sep | National<br>404 lakes | database & annual report; NIVA |
| L2 | 1000-lake survey | NIVA | chemical & biological variables | since 1986<br>SF: yearly | yearly 100 lakes, 1005 lakes app. every 10 yr | database & annual report; NIVA |
| L3 | Monitoring of Lake Mjøsa & its tributaries | NIVA | physical, chemical & biological variables | since 1971<br>SF: 2/month | 4 stations in lake,<br>6 in tributaries | database & annual report; NIVA |
| L4/ R9 | Monitoring of acidifica-tion & heavy metals in surface waters in the Nor-wegian-Russian border areas | NIVA | chemical & biological variables | since 1986<br>SF: lakes; 1-2/yr<br>rivers;<br>weekly-monthly | 40-50 sampling points in each country | database & annual report; NIVA |
| L5 | National survey on heavy metals in lake sediments and mercury in fish | NIVA | Metals in water and sediment, HG in fish | since 1986<br>SF: once | Nation-wide<br>210 lakes | Database & report: NIVA |
| L8/ R 11 | Monitoring of effects of acidification on fish stock in Norwegian inland waters (lakes and rivers) | NINA | Fish: species composition and abundance | since 1980<br>SF: Streams: 1/yr<br>Lakes: 1/2-5 yrs | Nation-wide<br>140 stream stations, 100 lake stations | Database & report: NINA |
| L9/ R 12 | Monitoring of liming projects in Norway | DN | Chemical and biological variables | Start one year prior to liming. SF variable | 12 liming projects, varying number of stations per project | Annual report: DN |

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|---|---|---|---|---|---|---|
| **Coastal and marine areas** | | | | | | |
| M1 | Trend monitoring of the Norwegian coastal areas | NIVA | physical, chemical & biological variables | 1990-1999<br>SF: twice a month | 30 stations, Southern Norway | Database & annual report; NIVA |
| M2 | Joint Monitoring Programme (JMP) | NIVA | organic & inorganic contaminants | since 1981<br>SF: annually | National coastal regions<br>115 stations | Database; local & ICES<br>Report; NIVA |
| M3 | Arctic monitoring & assessment programme | IMR | fish & sed: pesticides<br>$^{137}$Cs, heavy metals | since 1991<br>SF: 1/yr | 227 stations in Barents Sea & northern fjords | Database; AMAP Report; IMR |

| | | | | | | |
|---|---|---|---|---|---|---|
| M4 | Marine investigations along the west coast of Novaja Zemlya (AMAP) | Akvaplan-NIVA A/S | POC, heavy metals, sedimentation rates | since 1994<br>SF: 1/yr | 30 stations, west coast & fjords of Novaja Zemlya | Database; AMAP Report; Akvaplan-NIVA A/S |
| M5-M8 | Monitoring of<br>5. Grenlandsfjords, Telemark<br>6. Ranfjorden<br><br>7. Sørfjord & Hardangerfjord<br>8. Hvaler-Singlefjorden | NIVA | 5. contaminants in biota, phyto-/zooben, invert<br>6. hydrography, contaminants, invert., fish<br>7. chemical variables in water, mussels, seaweed, fish & sediment<br>8. contaminants in sediment/biota, phys/chem and biol. variables | 5: since 1975<br>SF: every 1-5 years<br>6: since 1975<br>SF:max 2 subseq. yr<br>7: since 1979<br>SF: water; 6/yr, biota; 1/yr sediment; 1/5 yr<br>8: since 1989<br>SF: water: 4-8/yr biota: 1/1-5 yr sediment: 1/1-5yr | 5: Grenland fjords, coast of Telemark<br>6: 26 sediment stations 21 biota stations<br>7: 150 km from the source of pollution in the fjords<br>8: Glomma estuary<br>Water: 9 stations<br>Sediment: 20 stations<br>Sed. traps: 40 stations<br>Biology: 51 stations<br>Poll. in biota: 11 stat. | Database & reporting; NIVA |

NIVA: Norwegian Institute of Water Research; NINA: Norwegian Institute for Nature Research; LFI: Laboratory for Freshwater Ecology and Inland Fisheries; SFT: Norwegian State Pollution Control Authority; NVE: Norwegian Water Resources and Energy Administration; DN: Directorate for Nature Management; IMR: Institute of Marine Research; ICES: International Council for the Exploration of the Sea; AMAP: Arctic Monitoring and Assessment Programme

**Lakes**

The national lake survey, L1, is mainly focused on eutrophication of lakes and the objectives are to establish a regional overview on distribution of and temporal changes in eutrophication in Norwegian lakes. The survey network includes 404 lakes that are studied every 3 to 4 years: four samples are taken in each year of study and the abundance of nutrients, phytoplankton, zooplankton and fish is measured. The L2 survey focuses on lake acidification. A nation-wide status based on sampling of 1,000 lakes is made every 10 years, the last time in 1986, and a selection of 100 lakes is used for trend analysis (yearly sampling). The water samples are analyzed for general physical and chemical indicators of acidification, and additionally bottom fauna and fish are studied. The L3 programme concerns monitoring of lake Mjøsa, the largest Norwegian lake, with special focus on eutrophication. The purpose of the L5 programme is to determine the state of pollution by heavy metals in sediment and fish in 210 Norwegian lakes. One survey has been carried out during the period 1986-1988.

**Marine areas**

The objectives of the M1 monitoring programme are to assess the state of eutrophication of coastal areas in southern Norway, while the M2 monitoring programme focuses on heavy metals and organic pollutants in the main Norwegian fjords. The M3 and M4 monitoring programmes are part of the Arctic Monitoring and Assessment Programme (AMAP) and involve monitoring and assessment of the levels of AMAP-relevant contaminants (heavy metals, organic micropollutants and radionuclides).

The fjord monitoring programmes, M5-M8, focus on monitoring of specific fjords and the major environmental problems related to these systems (eg. heavy metals, nutrients, organic micropollutants, etc.).

# Portugal

The mainland of Portugal has an area of 88,700 km$^2$ and 9.4 million inhabitants. It is bounded to north and east by Spain and to west and south by the Atlantic Ocean. The five largest rivers the Douro, the Tejo, the Guadiana, the Sado and the Mondego, which all have a Portuguese catchment area greater than 5,000 km$^2$, cover around three quarters of the Portuguese territory. Portugal has only few natural lakes, but nearly all the large rivers have several reservoirs, about 140 in all. Portugal has a long coastline along the Atlantic Ocean and some important estuarine areas.

**Inland surface waters**

Surface water quality monitoring is carried out by the Regional Directorates of Environment and Natural Resources (DRARN) within the geographical area of their authorities. Each DRARN has a surface water monitoring programme. A nation-wide water quality network (R1) has been established and is coordinated by the National Institute of Water (INAG). The national network is composed of the five regional monitoring networks (Norte, Centro, Lisboa e Vale do Tejo, Alentejo and Algarve). The national network consists of 109 sampling sites, primarily in large rivers (24 river systems). The most important reservoirs whose main use is domestic water supply are included in the R1 programme as well.

*Objectives*

The objectives of the monitoring programme are to assess the environmental state and trends of surface waters, to provide information to determine whether regional and national objectives and international legislation are complied with.

*Sampling and variables measured*

Sampling and analyses are undertaken by DRARN. Water samples are taken at monthly intervals and analyzed for general chemical and physical variables, organic pollution indicators, nutrients and some heavy metals. Harmonization and standardization of analytical methods has been carried out by INAG.

*Data storage*
The data are stored at regional level and sent to INAG with the aim of compilation and publishing.

*Transboundary rivers*
The most important Portuguese rivers are shared with Spain and the two countries are currently trying to reach an agreement on river monitoring. Automatic sampling stations with teletransmission and early alarm systems are planned to be installed. Since 1993 the National Institute of Water (INAG) has had the overall responsibility of management of transboundary rivers. The DRARNs have executive function and operational responsibilities in the geographical region within their authorities.

**Table 3.12:** National surface water monitoring programmes in Portugal

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & national reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | Water Quality Network<br>Rede de qualidade da água | INAG & DRARN | Chemical and physical variables | Since<br>SF: monthly | Nation-wide, 109 sampling sites in primarily large rivers | Database: DRARN<br>Reporting: INAG |

INAG: National Institute of Water; DRARN: Regional Directorate of Environment and Natural Resources

**Marine waters**
Monitoring of Portuguese marine waters is undertaken in a number of programmes covering coastal areas, estuaries and bathing waters. Only sparse information about the marine programmes has been received.

# Spain

Spain has a land area of 505,950 $km^2$ and a population (1986) of 39.0 million. It is bounded on Portugal to the west and by France to the north. The eight largest Spanish river systems drain approximately 362,000 $km^2$ or 72 per cent of the total land area. The Miño, the Duero, the Tajo, and the Guadiana rivers run from east to west either through or as a boundary river to Portugal before discharging into the Atlantic; the Guadalquivir also discharges into the Atlantic, while the Segura, the Júcar and the Ebro run from west to east and discharge into the Mediterranean. There are only a few big natural lakes in Spain and a modest number of small alpine lakes in the Pyrenees and the other mountain ranges. The greater part of the land area lacks natural lakes, although estuarian wetlands are of great ecological importance. Spain has, however, many reservoirs. On nearly all large rivers reservoirs have been constructed. Spain has around 1,000 large reservoirs with a surface area exceeding 8 $km^2$. The coastline of the Spanish mainland is around 3,900 km long, 20 per cent bordering on the Bay of Biscay, 30 per cent bordering on the Atlantic Ocean and the remaining half bordering on the Mediterranean.

**Monitoring of inland waters**
Spain is divided into ten hydrometric areas. Seven hydrometric areas are situated at the large river systems of the Duero, the Tajo, the Guadiana, the Guadalquivir, the Segura, the Júcar and the Ebro and three areas consist of several smaller river systems. The administration, control and surveillance of water quality are under the responsibility of the Water Commissioner within the different hydrographic areas.

Spain has a long tradition for national assessment of the chemical and physical quality of surface water (primarily rivers). In 1962 La Dirección General de Obras Hidráulicas (the Executive for Water Works) established a water quality monitoring network (Red COCA/R1) based on 50 sampling sites at which 18 variables were measured monthly.
In 1972 the monitoring network increased by 221 sampling sites. The chemical analyses of water samples are undertaken by los Laboratorios de las Comisarías de Aguas (the laboratories of the Water Commission). In 1979 la Sección de Control Analítico de las Aguas de la Comisaría Central de Aguas (Central Commission for Water, Department for Analytical Water Control) was established with a view to analyzing the results from the monitoring network, and the results are stored in a database in la Secretaría General Técnica del Ministerio (the Department for Data Management).

In 1981-82, a revision of the monitoring programme was conducted resulting in coordination and harmonization of the work undertaken by the various institutions co-operating in the monitoring programme. The sampling sites were classified into three groups: special sites, preference sites and basic sites and the sampling frequency was regulated according to the importance of the sampling sites and based on former water quality results.

*Reporting of information and data storage*
Since 1972/73 the Ministry of Public Works, Transportation and Environment (Ministerio de Obras Públicas Transportes y Medio Ambiente (MOPTMA)) annually edit a statistic yearbook (anuario estadístico) with the results of the analyses from all the

hydrographical areas. The results of the analysis are stored in a database kept by the Dirección General de Calidad de las Aguas del MOPTMA.

*Network and variables measured*
In 1994 the network consisted of 448 sampling sites in 226 rivers and 55 river systems. About 60 per cent of the sampling sites are located in the five largest river systems. More than 70 per cent of the sampling sites have catchment areas greater than 500 $km^2$. Monthly sampling for basic variables such as temperature, pH, and organic pollution indicators, are performed at 75 per cent of the sampling sites, while samples for analysis of nutrients, specific ions (Na, Ca, K, etc.), heavy metals and organic micropollutants generally are collected less frequent. These variables are, however, determined at monthly intervals on 25-30 percent of the sampling sites.

*Biological monitoring of river water quality*
In 1980 the Centro de Estudios y Experimentación de Obras Publicas (CEDEX) del MOPTMA initiated a biological monitoring and classification programme (ES-R2) including all main Spanish rivers. A total of 847 sampling sites are classified according to macroinvertebrate indices. Sampling is made four times annually and water quality maps are drawn annually.

**Table 3.13:** Spanish national surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency SF | Geographical coverage | Data & national reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| ES-R1 | Assessment of physico-chemical river quality | MOPTMA | Chemical and physical variables | Since 1962<br>SF: 1-12/yr | Nation-wide<br>448 sampling sites in all main Spanish rivers | Database: MOPTMA<br>Reporting annually |
| ES-R2 | Biological classification of river water quality | MOPTMA (CEDEX) | Macroinvertebrates | Since 1980<br>SF: 4/yr | Nation-wide<br>847 sampling sites in all main Spanish rivers.<br>160 sites/yr | Database: MOPTMA<br>Reporting annually |
| **Lakes and reservoirs** | | | | | | |
| ES-L1 | National survey on eutrophication in reservoirs | MOPTMA (CEDEX) | Physical, chemical and biological variables | Since 1972<br>SF: 4/yr | Nation-wide<br>350 reservoirs | Database: MOPTMA<br>Reporting annually |
| ES-L2 | National survey on eutrophication in reservoirs by remote sensing | MOPTMA (CEDEX) | Temperature, transparency, chlorophyll | Since 1984<br>SF: 4/yr in summer | Nation-wide<br>496 reservoirs, 1 river basin each year | Database: MOPTMA<br>Reporting annually |

MOPTMA: Ministerio de Obras Públicas e Urbanismo, Dirección General de Obras Hidráulicas; CEDEX: Centro de Estudios y Experimentaciónde Obras Públicas del MOPTMA.

**Lakes and reservoirs**
Some reservoirs are monitored according to the R1 programme, but no specific lacustrine monitoring programme exists. A national survey on eutrophication in 350 reservoirs (ES-L1) was initiated by the CEDEX in 1972, recording physical, chemical and biological variables. Furthermore, 496 reservoirs have been surveyed by remote sensing since 1986 (ES-L2) and data on temperature, transparency and chlorophyll have been recorded. Sampling frequencies in both programmes are four times a year.

**Marine waters**
No information about monitoring of marine areas has been reported by Spain. Spain participates in the Mediterranean Pollution Monitoring and Research Programme (MED POL/UNEP), both in the monitoring of coastal waters and in related research activities.

# Sweden

Sweden has a total area of 450,000 $km^2$ and covers almost 1,600 km from the north to the south. Sweden has 8.6 million inhabitants (1990). In northern Sweden a number of relatively large parallel rivers run from the western mountain ranges to the Gulf of Bothnia in the east, while the rivers in the southern part of the country are generally rather small. The greatest river is Göta Älv at the west-coast of Sweden with a drainage basin of about 46,830 $km^2$.

Lakes are typical of the Swedish landscape and provide substantial river water storage. 8.6 per cent of the total area of Sweden consists of lakes. The four largest lakes (Vänern, Vättern, Mälaren and Hjälmaren) represent a quarter of the total lake area. About 16% of the Swedish lakes are considered to be acidified.

The main Swedish marine areas are the Baltic, including the Gulf of Bothnia and the Baltic Proper, the Sound and the Belt Sea, the Kattegat and the Skagerrak.

**Administrative organization**
The chief responsibility for environmental matters at governmental level is vested in the Ministry of Environment. A great deal of the material for the Ministry of Environment bills is provided by the Swedish National Environmental Protection Agency, the central government authority for environmental matters. The agency is also responsible for advising and providing information on local environmental work. Moreover, the Environmental Protection Agency supports environmental research and monitoring, not least regarding the effects of various protective measures. The Swedish Environmental Protection Agency has the overall responsibility for the National Monitoring Programme that provides the national overview and forms the basis for reporting to international organizations.

Responsibility for routine environmental protection work has increasingly been decentralised and handed over to regional and local authorities. The 24 County Administrative Boards are chiefly responsible for regional matters including continuous monitoring of environmental quality in their areas. They also make a wide range of decisions about licences for hazardous enterprises and also check that environmental laws are followed.

**Inland surface waters**

*National monitoring of rivers and lakes*
The Swedish Environmental Protection Agency (SNV) has the overall responsibility for the management of the National Monitoring Programme. The monitoring of fresh waters is undertaken by the Swedish University of Agricultural Sciences, Department of Environmental Assessments (SUAS) on a contractual basis. The monitoring data are presently stored by SUAS, but will in the near future be transferred to an appointed data host. The data host will be responsible for the filing and storing of the data and for the distribution of data to different consumers.

Environmental assessments of the freshwater environment, based mainly on the results from the National programme, are performed every year by the SUAS in co-operation with the SNV.

Sweden has four national inland surface water monitoring programmes (Table 3.14). The objectives of the nation-wide L1/R1 survey programme are to describe the chemical (nutrients, acidification, cations, etc.) and biological (macroinvertebrate) state of Swedish lakes and streams by doing an extensive survey of randomly sampled sites once every five years. The survey is based on sampling of 1,000 lakes and 300 streams.

The L2/R2 monitoring programme provides an annual description of the chemical (nutrients, acidification, cations, heavy metals, etc.) and biological (macroinvertebrate, fish phytoplankton) variation in time as a result of changes in deposition, climate, biology and land-use. The network consists of 85 lakes (4 annual samples) and 35 streams (12 annual samples). The L3/R4 monitoring programme is an extension of L2/R2 including more variables to be measured and more frequent sampling. This programme consists of 15 lakes and 15 streams. The monitoring programme R4 quantifies on an annual basis the amount of substances being transported to the surrounding coasts of Sweden. Fortynine main rivers along the coast are sampled monthly and analyzed for nutrients, suspended matter and heavy metals.

*Regional monitoring of rivers and lakes*
The County Administration Boards are responsible for the Regional Monitoring Programmes aimed providing more detailed information on environmental conditions within the counties. In addition, there are Coordinated Local Monitoring Programmes that are made with a view to special types of emissions or situations requiring particularly detailed studies for some other reason.

The monitoring is performed and evaluated by different institutes and consultants on a contractual basis. In some cases the County Administration Boards are performing the monitoring themselves. Data are being stored both at the County Administrative Board and at different institutes and consultants. The different institutes and consultants are reporting the information to the County Adminstration Boards that in connection with some sub-programmes distribute the data the Swedish Environmental Protection Agency and a national data host. The results from the Regional and Local Monitoring Programmes are published as regional reports by the County Administrations.

**Table 3.14:** National surface water monitoring programmes in Sweden.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Lakes and streams** | | | | | | |
| L1/ R1 | National - lake & stream survey | SUAS | physical & chemical variables, macroinv. | since 1972; SF: every five yr | National - 1000 lakes, 300 streams | database; SUAS Report every fifth yr; SUAS |
| L2/ | National time-series in | SUAS | physical, chemical & | since 1960s | National - 85 lakes, | database; SUAS |

| | | | | | | |
|---|---|---|---|---|---|---|
| R2 | reference lakes & streams | | biological variables, sediment, palaeo-reconstruction | SF: 4-12/yr, depends on parameter | 35 streams | Report 1/yr; SUAS |
| L3/ R3 | National intensive time-series in reference lakes & -streams | SUAS | physical, chemical & biological variables, sediment, paleo-reconstruction, conta-minants in fish | since 1960s<br>SF: 1-12/yr, depends on parameter | National - 15 lakes, 15 streams | database; SUAS<br>Report 1/yr; SUAS |
| **Rivers** | | | | | | |
| R4 | National main-river outlets | SUAS | physical & chemical variables | since 1960s<br>SF: monthly | 49 main rivers | database; SUAS<br>Report 1/yr; SUAS |
| **Coastal and marine areas** | | | | | | |
| M1 | National pelagic high frequency monitoring | UMSC, SMSC, GMSC | physical, chemical & biological variables | GB: since 1989<br>BP: since 1976<br>K&S: since 1993<br>SF: 8-25/yr | three coastal & five offshore stations | Database & annual report; UMSC, SMSC, GMSC, SMHI & RSAS |
| M2 | National pelagic frequent monitoring | UMSC, SMHI | physical & chemical variables | since 1992; GB<br>since 1993; BP, K&S<br>SF: 6-12/yr | GB; 10 stations<br>BP; 12 stations<br>K&S; 3-4 stations | Database & annual report; UMSC & SMHI |
| M3 | National pelagic low frequent monitoring | SMHI | physical, chemical & biological variables | since 1993<br>SF: 6-12/yr FS<br>SF: 1/yr LFS | GB, BP, the Sound, K&S; FS: 25 stations, LFS: 68 stations | Database & annual report; SMHI |
| M4 | National soft bottom macrofauna | UMSC, SMSC, GMSC | zooben, splist, cnr, EH, sal, tempw, macrofauna, sediment | since: BP; 1980, GB, K&S; 1983,<br>SF: 1/yr May-June | offshore & coastal waters | Database & annual report; UMSC, SMSC, GMSC |
| M5 | National phytobenthos | SMSC, GMSC | plants & animals, substratum, sal, secchi. | since ?<br>SF: 1/yr August | The Baltic Proper & the Skagerrak | Database & annual report; SMSC, GMSC |
| M6 | National malformed embryos of *Monoporeia affinis* | IAER | no. of eggs & abnormal embryos | since 1993<br>SF: 1/yr February | 5 stations in GB,<br>7 stations in nBP | Database & annual report; IAER |
| M7 | National ecological coastal fish monitoring | NBFI | fish stock & individual analysis | since 1989<br>SF: 1-2/yr | one coastal area in BP, GB & the Skagerrak | Database & annual report; NBFI |
| M8 | National physiological coastal fish monitoring | IAER, GMSC | blood & tissue consti-tuents | since 1989<br>SF 1/yr summer | one coastal area in BP, GB & the Skagerrak | Database & annual report; IAER, GMSC |
| M9 | Contaminant monitoring programme | IAER, SMNH, SUAS | contaminants (heavy metals, pesticides) in biota | since 1979<br>SF 1/yr in autumn | GB, BP, K&S | Database & annual report: IAER, SMNH, SUAS |
| M 10 | Monitoring of top predators (seals and eagles) | SMNH | Population size and dynamics. Health status. | Since 1989<br>SF 1/yr | GB, BP, K&S | Database & annual report: SMNH |

GB: Gulf of Bothnia; nBP: northern Baltic Proper; BP: Baltic Proper; K&S: Kattegat & the Skagerrak; FS: Frequent Sampling; LFS: Low Frequent Sampling; SUAS: The Swedish University of Agricultural Science, Department of Environmental Assessments; UMSC: Umeå Marine Science Centre; SMSC: Stockholm Marine Science Centre; GMSC: Gothenburg Marine Science Centre; IAER: Institute of Applied Environmental Research, University of Stockholm; SMHI: The Swedish Meteorological & Hydrological Institute; NBFI: The National Board of Fisheries, Institute of Coastal Research; SMNH: The Swedish Museum of Natural History, Contaminant Research Group.

*Transboundary waters*

Only a few river basins are shared with neighbouring countries; the areas of main concern being the river Torneälv forming the border between Finland and Sweden, and the river Göta Älv that captures much of its discharge while passing through Norway.

According to an agreement between Sweden and Finland, a special court (The Finnish - Swedish River Commission) is exclusively competent in water cases and in matters pertaining to the prevention of water pollution of frontier rivers. Sweden and Norway have also agreed upon special regulations to ensure that the interests of both countries are considered in matters of water structures affecting them both.

**Marine waters**

*National monitoring*

The Swedish Environmental Protection Agency (SNV) has the overall responsibility for the management of the National Monitoring Programme. The monitoring is performed by a number of institutions on a contractual basis.

Environmental assessments of the marine environment, based mainly on the monitoring results from the National Programme, are performed every year by the three Marine Science Centres of Umeå, Stockholm and Gothenburg that cover the Gulf of Bothnia,

the Baltic Proper and the Sound, the Kattegat and the Skagerrak, respectively. The assessments are made in co-operation with the SNV.

Efforts are made to co-ordinate and integrate parts of the National Programme into the regional coastal programmes in order to obtain one Marine Monitoring Programme covering Swedish Territorial Waters.

The whole monitoring-system in Sweden is now being harmonised by setting up a common manual for environmental monitoring that is valid for monitoring at all levels within the administration. All laboratories have to be certified for the analyses they are performing, provided that a certification exists. A biological certification has not yet been established. The certification includes annual intercalibrations.

Sweden has three national monitoring programmes focuse on the pelagic of the marine areas (M1-M3). The main purposes of the monitoring are to assess the state of eutrophication and the occurrence of toxic algal blooms. The intensive programme, M1, includes three coastal and five offshore sampling sites involving frequent sampling (25/yr), analyses for general physical and chemical variables and nutrients, and studies of phytoplankton and mesozooplankton composition. The M2 network consists of 35 offshore stations that are sampled 6-12 times annually at which measurements of general physical and chemical variables and nutrients are made. The M3 programme consists of two networks: a frequent sampling network with 25 offshore stations and a low-frequent sampling network including 68 mapping stations. Sampling frequency varies from 6-12 times at the frequent sampling sites to one annual sample at the mapping sites. Water samples are analyzed for indicators of eutrophication.

The objectives of the M4 monitoring programme are to observe long-term trends related to primarily eutrophication and oxygen deficits. Once a year samples of macrozoobenthos are collected at a number of sites both in offshore areas and in the coastal zone. The M5 monitoring programme is also aimed at studying the effects of eutrophication based on distribution, abundance and biomass of phytobenthos (Macroalgae). Stock analysis and individual analysis of fish fauna are undertaking in the M7 and M8 monitoring programmes. The M9 and M10 programmes are following the long-term trends in relation to toxic substances.

# The United Kingdom

The United Kingdom has a land area of 240,000 $km^2$ and a population of 57 million (1990). The long coastline of the British Isles compared to the land area means that the United Kingdom is dominated by numerous relatively small river systems. Only three river systems, the river Thames, the Severn and the Trent, have a catchment area exceeding 10,000 $km^2$, but comprise only around 7 per cent of the total land area. England and Wales have few natural lakes, while numerous lakes (lochs) can be found in Scotland. The largest lake of the British Isles, Lough Neagh, with a surface area exceeding 300 $km^2$ is located in Northern Ireland. Several estuaries are located along the British coastline; the major ones being the Clyde, the Forth and the Tay on the Scottish coast, and the Severn, the Humber, the Wash, the Thames, the Mersey, the Tyne and the Tees estuaries on the English and Welsh coast. The major seas surrounding the British Isles are the North Sea to the east, the English Channel to the south, Bristol Channel, St. George Channel, the North Channel, the Irish Sea and the Atlantic Ocean to the west.

**Monitoring of surface waters**
In the United Kingdom the national responsibility for the control of pollution in all inland and coastal waters is divided into three regions: England and Wales, Scotland and Northern Ireland.

England and Wales: The National Rivers Authority (NRA) is responsible for maintaining and improving water quality and for pollution control, water resources, flood defence and fisheries, navigation, conservation and recreation. The NRA was formed in 1989 from what were, briefly, the ten River Units of the regional Water Authorities in England and Wales. The regional pattern has been retained by NRA, although some mergers have taken place.

*Rivers and coastal waters*
There has been a long tradition for monitoring the environmental state of English and Welsh surface waters. A series of surveys have been carried out since 1958 in England and Wales with the specific aim of assessing the overall quality of rivers, canals and estuaries. Since 1970 surveys have been carried out at five year intervals. These categorize estuaries into four quality classes, and rivers and canals into six classes.

Scotland: The River Purification Authorities (RPA's), comprising the seven River Purification Boards and the three Islands Councils are responsible for maintaining and improving the quality of the water environment and for water pollution control.

*Rivers and coastal waters*
The Scottish RPBs have a well-established network of monitoring stations, many having data records covering more than 20 years and some even more than 30 years. More than 1,000 river stations are sampled monthly or quarterly with a view to chemical analyses, and biological surveys are carried out at more than 900 sites. Fifty six river stations of the Harmonised Monitoring System are located in Scotland. Marine pollution monitoring is carried out at several hundred sites and at varying depth in estuarine and coastal waters.

In Scotland surveys similar to those in England and Wales have been carried out since 1968. The surveys assess the overall quality of rivers, canals and estuaries with a separate biological survey being carried out in 1980 and 1990. The chemical surveys comprise approx. 2800 river sites.

Northern Ireland: The Department of the Environment for Northern Ireland (DoE(NI)) is responsible for water quality and pollution control, water resources and conservation.

*Rivers and coastal waters*
DoE(NI) monitors both river and coastal waters. River quality monitoring has on a routine basis been carried out in Northern Ireland since 1973. In 1994, approx. 290 river quality monitoring sites were sampled regularly and the samples analyzed for up to 18 variables such as Biochemical Oxygen Demand, dissolved oxygen, ammonia, suspended solids, etc. Quantity and quality data are kept in a computer database and information is published for public information.

The major monitoring activities in England and Wales, Scotland and Northern Ireland have been compiled to provide a national overview of surface water monitoring programmes in the United Kingdom (Table 3.15). Other activities exist, including monitoring of coastal areas by NRA, monitoring of radioactivity by MAFF and several programmes arising from EU directives.

**Rivers and canals**
Three monitoring programmes are focused on assessment of the environmental state of rivers and canals (R1-R3). The R1 Harmonised Monitoring Programme is a national archive of water quality data maintained by the Department of Environment aimed at providing information on rivers throughout the United Kingdom and satisfying certain international obligations, including the estimation of riverborne input of selected contaminants to the sea. The data are also used to investigate long-term trends in main determinands. The sampling network includes 230 sites, mainly located on major rivers at, or near, the tidal limit. The programme was established in 1974 and is based on sampling and chemical analyses made in the various NRA regions and RPBs. The sampling frequency varies substantially, but it typically lies within the range of 6 to 52 per year. The monitoring programme may embrace a wide range - over 80 - of physical and chemical attributes of river quality, but typically only 25 are measured at any given site. A number of determinands are measured as standards, but a larger proportion is monitored only if considered necessary.

The objectives of the R2 monitoring programme are to accurately assess and regularly report on the general state of rivers and canals regardless of the use to which waters may be put. The network includes approximately 92,500 km of rivers and more than 10,000 sampling sites. Sampling sites are classified according to a General Quality Assessment (GQA) scheme. Chemical quality assessment is based on the organic pollution indicators: BOD5, dissolved oxygen and ammoniacal nitrogen. Additional variables are measured and have an associated long time series of data, and further 'windows' of quality assessment based on some of these variables will be added, covering biology, nutrients and aesthetic quality. The objectives of the R3 monitoring programme are to assess the biological quality of rivers and canals by the use of macroinvertebrates. Sampling sites are assigned an index value according to the Biological Monitoring Working Party (BMWP) score system. The chemical programme, R2, and the biological programme, R3, are complementary.

**Lakes and reservoirs**
No general national lake monitoring programme exists. Many lakes in the United Kingdom have been monitored and classified as a part of associated river systems. Monitoring of reservoirs and other lakes has been carried out mainly on an ad hoc basis according to local needs and circumstances. The objectives of the L1 monitoring programme are to assess and monitor the occurrence of potentially toxic blue-green algae.

**Marine waters**
The purposes of the main national marine monitoring programme, M1, are to assess the spatial distribution of contaminants in different areas of UK waters and their biological state and thus identify areas of specific concern; to detect trends in contaminant concentrations and biological well-being in areas identified as being of concern; to measure long-term trends in physical, biological and chemical variables at selected areas. The network includes 100 sites in estuaries, inshore and offshore coastal areas around the UK with sampling of the water column, the sediment and the biota and measurements of various contaminants.

**Table 3.15:** National surface water monitoring programmes in the United Kingdom.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| R1 | The Harmonised Monitoring Programme | DoE, NRA<br><br>SOEnD, RPB | over 80 physical and chemical attributes of river quality, but typically only 25 are measured at any given site | Many sites since 1975<br><br>SF: 6-52/yr | A national network covering Great Britain<br><br>220-230 sampling sites | |
| R2 | General Quality Assessment (GQA) | NRA<br><br>SOEnD, RPB | OX, OXSAT, BOD5, NH4N, and variables appropriate to the | Since 1976 | England & Wales:<br>40,000 km of rivers and canals, approx. 7,000 | Database: NRA, SOEnD, DoE(NI) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Chemical assessment of rivers, canals and lochs | DoE(NI) | stretch in question | SF: 12/yr (4-24/yr) | sites<br>Scotland<br>50,000 km of rivers and canals, approx. 2800 sites<br>Northern Ireland<br>2,500 km of rivers, approx. 290 sites | Reporting: NRA, SOEnD, DoE(NI) |
| R3 | General Quality Assessment (GQA)<br><br>Biological classification of rivers | NRA<br><br>SOEnD, RPB<br><br>DoE(NI) | macroinvertebrates | Start year: 1990<br><br>Every 5 year two or three annual samples | England & Wales:<br>40,000 km of rivers and canals, approx. 7,000 sites<br>Scotland<br>11,000 km of rivers, 976 sampling sites<br>Northern Ireland<br>2,500 km of rivers, approx. 290 sites | Database: NRA, SOEnD, DoE(NI)<br><br>Reporting: NRA, SOEnD, DoE(NI) |
| **Lakes and reservoirs** | | | | | | |
| L1 | Blue-green Algae Annual Sampling Programme | NRA<br><br>DoE(NI) | Blue-green algae, water samples, bloom and/or scum material | England & Wales<br>Start year 1989<br>Routine sampling and reactive sampling<br>Northern Ireland<br>1993: Routine monitoring programme<br>From 1994: only reactive monitoring<br>Scotland<br>Routine monitoring | England & Wales<br>NRA regions<br>Northern Ireland<br>1993: 52 water abstractions and 17 recreational waters.<br>Scotland<br>Waters considered to be at risk. | Data held by NRA & DoE(NI), no public report |
| L2 | Monitoring of inland waters commonly used for recreation | DoE(NI) | Microbiological indicators & blue-green algae | Since 1992<br>SF: 5/yr | Northern Ireland<br>14 waterbodies, 31 sites | Data held by DoE (-NI), no public report |
| **Coastal and marine areas** | | | | | | |
| M1 | UK National (Marine) Monitoring Plan (UK NMP) | MPMMG | Organic & inorganic variables in water column, sediment, shellfish & fish | Data from at least 1988<br>SF: water 1-4/yr, sediment 1/yr, biota 1-2/yr | Approx. 100 sites in the upper, middle and lower reaches of estuaries, inshore and offshore coastal sites around the UK | Central database being developed<br>No UK report, Data passed to the North Sea Task Force |
| M2 | Water classification of estuaries | SOEnD, RPB<br>NRA<br>DoE(NI) | Use related descriptions, aesthetic, biological, bacteriological, and chemical conditions | Start year 1985<br>Every 5 year<br>SF: 4/yr, variable in Scotland | All Scottish estuaries exceeding 1 km<br>28 estuaries in England and Wales<br>All 7 N.Ireland sea loughs and estuaries | Database: SOEnD, NRA, DoE(NI)<br><br>Reporting: SOEnD, NRA, DoE(NI) |
| M3 | Classification of coastal waters | SOEnD, RPB | Use-related descriptions, aesthetic, biological, bacteriological, and chemical conditions | Start year 1990<br>Every 5 years<br>SF: variable | Coastal waters of Scotland<br>Approx 7,000 km length | Database: SOEnD, NRA, DoE(NI)<br><br>Reporting: SOEnD, NRA, DoE(NI) |
| M4 | Marine Algae Monitoring Programme | NRA<br><br>DoE(NI) | Marine Algae | Since 1991<br>Weekly from May to September | England & Wales<br>615 identified and non-identified bathing waters<br>Northern Ireland<br>16 identified and<br>10 non-identified bathing waters | Summary data held nationally<br><br>Annual internal report |
| M5 | Monitoring of Bathing waters. | NRA, RPBs | Bacteria, organic pollution | 20 times a year during the bathing season | 460 bathing waters in England + Wales(421), Scotland(23), and N.Ireland(16) | Annual reporting |
| M6 | Water Quality of Shellfish Waters. | NRA | Heavy metals, organic micropollutants | SF: Variable 2-12/yr | 29 shellfish waters | Annual reporting |

DoE: Department of Environment; NRA: National River Authority, England and Wales; SOEnD: The Scottish Office Environment Department; RPB: River Purification Boards, Scotland; DoE(NI): Department of Environment, Northern Ireland; MPMMG: Marine Pollution Management Monitoring Group;

# International monitoring programmes

Several international monitoring programmes are in operation in the European Environment Agency area. Some monitoring programmes are operated by international organizations, such as the Commission of European Commissions (CEC), the United Nations Environmental Programme (UNEP) and the OECD, and are primarily based on collection of results from national monitoring activities, the results being used for global and regional analysis and reporting.

Countries situated in the catchments of transboundary rivers and lakes or countries sharing marine areas usually establish some form of environmental cooperation as is the case with, for example, the Danube, the Rhine, Lake Constance, Lake Geneva, the Baltic, the North Sea, the North East Atlantic and the Mediterranean. Generally, such cooperation has resulted in the establishment of a monitoring programme covering the specific waterbody.

In the following sections some of the main international monitoring programmes are briefly described. Generally, the monitoring activities are numerous and cover many purposes and include therefore several sampling networks and analysis programmes. Additionally, the monitoring programmes are continuously changing according to the environmental issues in question. More detailed information about the monitoring programmes may be obtained from the responsible organizations.

**Inland surface water monitoring programmes**

*European Union river network (EU-R1)*
Council Decision no 77/795/EEC of 12 November 1977 established a common procedure for the exchange of information on the quality of surface fresh water, the three principle objectives of which are: (1) to determine the levels of pollutants in the rivers of the community and consequently lay down guidelines for the control of pollutants and nuisances; (2) to monitor long-term trends and improvements resulting from the application of current national and Community legislation; (3) to allow for as significant a comparison as possible of the results of the measurements obtained at the sampling or measuring station.

One hundred and twentysix sampling sites mainly situated in large Member State rivers are included in the exchange of information. The number of sampling sites vary from one sampling site in Luxembourg to four sampling sites in Denmark and Ireland, and 15, 16 and 17 sampling sites in Spain, France and the United Kingdom, respectively. At the selected sampling sites each country takes water samples at monthly intervals and analyses these for general chemical and physical variables. Each Member State must send to the Commission data relating to certain physical (eg. water flow, pH, and conductivity, etc.), chemical (eg. organic pollution indicators, nutrients, heavy metals, etc.) and microbiological variables (eg. coliforms, streptococi bacteria, etc.). Every three years the Commission analyzes the information supplied and prepares a report.

*GEMS/WATER*
The Global Environmental Monitoring System (GEMS) is a collective effort of the world community to acquire, through monitoring, the data needed for assessment and rational management of the environment at global, regional and national level. GEMS/WATER, the network of surface and ground water quality monitoring stations, was established jointly in 1977 by UNEP, WHO, WMO and UNESCO. On a world-wide basis 60 countries currently participate in the GEMS/WATER programme, the global network including about 360 surface water sampling sites. GEMS/WATER has two main objectives; global water quality assessment and strengthening of the national water quality programmes. The GEMS/WATER programme includes 31 water quality variables. Each country provides information on as many as variables as possible to the global databank. The collected information is analyzed and reported as global or regional assessments of water quality, an important result being the first assessment of water pollution issues on a global scale published in 1989 (Meybeck et al. 1989)

**Table 3.16:** International inland surface water monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Rivers and streams** | | | | | | |
| EU-R1 | EU river network.<br>Exchange of information<br><br>Council Decision no 77/795/EEC 1977 | CEC<br>and Member States | 18 physical, chemical, and microbiological variables | Since 1977<br>Portigal and Spain from 1986<br>SF: monthly samples | Large rivers in the EU Member States<br>126 sampling sites | Database: CEC<br>Reporting: every three years by the CEC |
| | Global Environment Monitoring System GEMS /Water | WHO & UNEP - GEMS/WATER Collaborating Centre Canada | Major ions (7)<br>Metals (12)<br>Nutrients (3)<br>Organic micropollutants (5)<br>Basic variables (4) | Since 1977 | 60 countries, world-wide, currently participate in the GEMS/WATER programme and around 360 surface water sampling sites are included | |
| | OECD | OECD | | | Rivers in the member countries. | Reporting every 5 years by OECD |
| R-R1 | Rhine | ICPRP | Water: 61 chemical and physical variables<br>Suspended solids: 30 chemical and physical variables | Since<br>SF: Water 12/yr to continious<br>Suspended solids 12-24/yr | 9 sampling sites on the main course of the river Rhine | Database: ICPRP<br>Reporting annually by ICPRP |
| | Elbe | ICPE | 10 heavy metals,<br>16 organic micropollutants and<br>5 biological variables | | 16 sampling sites | Database: ICPE<br>Reporting: ICPE |
| | Danube<br>Bucharest Declaration | | Chemical and physical variables.<br>Nutrients, heavy metals, organic micropollutants and petroleum products<br><br>Specific surveys performed in 1991-92. | Since 1988 | 11 sites | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Lakes and reservoirs** | | | | | | |
| | Lake Constance/Bodensee | IKGB | Eutrophication variables, oxygen, major ions, heavy metals, organic micropollutants, radionuclides<br><br>Hydrobiological and microbiological variables (phyto- & zooplankton, bacteria) | | Lake Constance<br>3 water sampling sites | |
| | Lake Geneva/Lac Léman | ICPGP | Water quality variables including eutrophication variables, heavy metals and organic micropollutants<br><br>Hydrobiological and microbiological variables.<br><br>Sediment monitoring | | Lake Geneva<br>1 water sampling site & 200 sediment sampling sites | |

CEC: Commission of European Communities;
IKGB: International Gewässerschutz-Kommission für den Bodensee/International Commission for Protection of Lake Constance;
ICPGP: International Commission for Protection of Lake Geneve against Pollution
ICPRP: International Commission for Protection of the Rhine against Pollution;
ICPE: International Commission for Protection of the Elbe

*OECD*
The Organisation for Economic Co-operation and Development (OECD) has since the 1970s collected annual average water quality data from large rivers and lakes in the Member States. The results from this inventory are reported every five years in the OECD Environmental Statistical Compendium. In the 1995 Statistical Compendium data for the period 1980 to 1993 from 138 rivers in 28 countries and 92 lakes in 25 countries was reported.

*Transboundary rivers and lakes*
The integrated management of transboundary water courses takes place in Europe within the framework of international commissions as far as entire river basins are concerned or bilaterally for waters forming the border to another country. A few international monitoring programmes are described in Table 3.16, while some bilateral monitoring programmes are described in the previous sections.

The R-R1 monitoring programme for the Rhine is one of the longest operating monitoring activities in the world. It is coordinated by the International Commission for the Protection of the Rhine against Pollution (ICPRP) and includes nine sampling sites along the main course of the river Rhine. At these sampling sites the involved countries, ie. Switzerland, Germany, France and The Netherlands, perform a standardized sampling and analysis programme including measurements of around 60 water quality variables. The results of the monitoring are reported annually by the ICPRP. Several other large transboundary rivers have similar international monitoring programmes, examples being monitoring of the Elbe and the Danube (Table 3.16). Prominent examples of the monitoring of transboundary lakes include Lake Constance and Lake Geneva. The programmes are carried out in compliance with the policy of the International Commission for Protection of Lake Constance and the International Commission for Protection of Lake Geneva against Pollution.

**Marine monitoring programmes.**

*OSPARCOM*
The Oslo Convention (Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (1974)) and the Paris Convention (Convention for the Prevention of Marine Pollution from Land-Based Sources (1978)) provide the regulatory framework for the protection against pollution of the maritime area of the North East Atlantic. The Commissions established by the Conventions carry out programmes to assess the state of the marine environment and formulate policies to eliminate or reduce existing pollution and prevent further contamination of coastal waters and the open sea.

Under the Joint Monitoring Programme (JMP) established by the OSPARCOM in 1978, Contracting Parties undertake the monitoring of the marine environment for the following purposes: (a) assessment of possible hazards to public health; (b) assessment of damage to living resources and marine life; (c) assessment of the existing level of marine pollution (geographical baseline studies); (d) assessment of the effectiveness of the measures taken to reduce marine pollution within the framework of the Conventions (trend monitoring). Depending on the purpose, each assessment is based on regular monitoring of one of several components of the marine environment: organisms, seawater and sediments.

*North Sea Task Force*
Members of the Task Force include the eight North Sea States (Belgium, Denmark, Germany, France, The Netherlands, Norway, Sweden, and the United Kingdom) as well as representatives of the Commission of European Communities, ICES (the Inter-

national Council for Exploration of the Sea) and the OSPARCOM (the Oslo and Paris Commissions). The objectives of the Task Force are: "to carry out work leading, in a reasonable time scale, to a defendable and comprehensive statement of circulation patterns, inputs and dispersion of contaminants, ecological conditions and effects of human activities in the North Sea".

The Monitoring Master Plan of the North Sea Task Force (MMP) was formulated in 1989. The plan is a constituent part of the JMP, but with the next Quality Status Report in mind, it includes provision for more comprehensive monitoring. The MMP has two main objectives: firstly, to provide the information necessary to assess the condition of the North Sea, and secondly, to provide the basis for future programmes that will permit temporal trends in physical, chemical and biological variables to be assessed.

Monitoring sites were selected in order to cover the open North Sea and the coastal areas where transects have been placed in front of the main estuaries. As a core programme to be used on an international scale, the MMP aims at coordinating both chemical and biological monitoring throughout the North Sea area. The mandatory list of determinands to be monitored under the MMP includes metals, organic micropollutants, nutrients and related interpretation variables such as salinity and grain size distribution. The concentration and spatial distribution were measured in sediments as well as in biota, and to a less extent in sea water. A voluntary list of items to be measured wherever possible includes additional chemical and biological variables to be monitored in relation to eutrophication phenomena. The biological part of the MMP includes studies of zoobenthos in relation to contaminant sources, fish diseases, introduction of a detoxification enzyme (EROD) in flatfish livers, and a water quality assay using oyster embryos.

*HELCOM*
The Baltic Monitoring Programme coordinated by the Helsinki Commission (HELCOM) has been operating since 1979 and focus on the input of harmful substances to the Baltic Sea. In 1988 the participating countries adopted the Declaration on the Protection of the Marine Environment of the Baltic Sea Area, which prescribes a substantive reduction, in the order of 50%, of the anthropogenic load of pollutants, especially the substance groups heavy metals, toxic or persistent organic compounds and nutrients, as soon as possible but not later than 1995.
In order to follow the state and trends of the Baltic Sea area and to get detailed descriptions of the loading, the monitoring programme includes monitoring in both marine areas and rivers. Nine countries around the Baltic Sea area contributes to the programme.

*MED POL*
The long-term programme in pollution monitoring and research in the Mediterranean, MED-POL, was initiated in the 1970s. First with a pilot phase mainly focused on an assessment of the pollution load reaching the Mediterranean. Monitoring of the Mediterranean pollution within the framework of MED POL started in 1983 through the implementation of National Monitoring Programmes and at present 16 countries have on-going programmes. The monitoring activities can be divided into the following groups (1) monitoring of sources of pollution providing information on the type and amount of pollutants released directly into the environment; (2) monitoring of nearshore areas, including estuaries, under the direct influence of pollutants from identifiable primary (direct point sources) and secondary (rivers) sources; (3) monitoring of offshore areas (reference areas) providing information on the general trend in the level of pollution in the Mediterranean; (4) monitoring of the transport of pollutants to the Mediterranean through the atmosphere. Through this programme pollution is regularly monitored at hundreds of sampling sites. Further information can be found in Jeftic (1993) in which a review of the MED POL monitoring activities can be found.

**Table 3.17 :** International marine monitoring programmes.

| No. | Name | Responsible institution | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage | Data & reporting |
|---|---|---|---|---|---|---|
| **Coastal and marine areas** | | | | | | |
| | OSPARCOM Joint Monitoring Programme (JMP) | OSPARCOM, ICES, 11 countries: IS, IE, UK, NO, DK, DE, NL, BE, FR, ES, PT | | Since 1978 | North East Atlantic | |
| | North Sea Task Force Monitoring Master Plan (MMP) | NSTF, ICES, 8 countries: BE, DE, DK, FR, NL, NO, SE, & UK | | Since 1989 | The North Sea | |
| | HELCOM Baltic Monitoring Programme (BMP) | HELCOM, 9 countries: SE, FI, RU, EST, LAT, LIT, POL, DE, DK | Variables related to input and level of harmful substances, especially heavy metals, organic micropollutants and nutrients. | Since 1979 | The Baltic Sea | |
| | MED-POL | UNEP/MED-POL & 16 countries | (1) monitoring of sources of pollution providing information on the type and amount of pollutants released directly into the environment; | | Mediterranean | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (2) monitoring of near-shore areas, including estuaries, under the direct influence of pollutants from identifiable primary (direct point sources) and secondary (rivers) sources;<br>(3) monitoring of offshore areas (reference areas) providing information on the general trend in the level of pollution in the Mediterranean;<br>(4) monitoring of the transport of pollutants to the Mediterranean through the atmosphere. | | | |

CEC: Commission of European Communities; OSPARCOM: Oslo and Paris Commissions; NSTF: North Sea Task Force;
HELCOM: Helsinki Commission; BE: Belgium; DE: Germany; DK: Denmark; ES: Spain; EST: Estonia; FI: Finland; FR: France; ICES: The International Council for Exploration of the Sea; IE: Ireland; IS: Iceland; LAT: Latvia; LIT: Lithuania; NL: The Netherlands NO: Norway; POL: Poland; PT: Portugal; RU: Russia; SE: Sweden; UK: United Kingdom;

# 4. Monitoring programmes

In the following chapter the monitoring programmes mentioned in the previous chapter are categorised according to the waterbody (ie. rivers, lakes, coastal areas and open marine areas) and the variables measured, respectively. Similar monitoring programmes are put together and similarities and differences according to network set-up, sampling frequency and variables measured are analyzed. The monitoring programmes have been categorised into the following main groups:

- Chemical and physical assessment of river water quality
- Biological assessment of river quality

- Chemical and physical assessment of lake water quality
- Biological assessment of lake quality

- Acidification of inland surface waters

- Chemical and physical assessment of marine water quality
- Biological assessment of marine quality

- Monitoring of organic micropollutants, radioactivity and microbiological indicators.

## 4.1 Chemical and physical assessment of river water quality

Nearly all the countries in the EEA area have a national monitoring programme with the purpose of assessing the chemical and physical water quality of rivers. Additionally some international programmes, such as the EU river network (pursuant to the Council Decision 77/795/EEC) and the OECD and GEMS/WATER networks, focus on the chemical and physical water quality in primarily large rivers. Some countries have a long tradition for national coordination of their river water quality monitoring programmes. Finland and Spain, for instance, initiated their national monitoring activities in the early 1960s. Most of the other countries also have a long tradition for monitoring the chemical quality of river water, however, this has traditionally been performed by regional or local institutions. During the 1980s the growing need for national river water quality information made these countries initiate national monitoring programmes. In most cases these river monitoring programmes are based on the information collected by regional organizations.

In Table 4.1.1 37 monitoring programmes with the purpose of chemical and physical assessment of river water quality are listed. For each country is first listed the main national monitoring programme (generally assigned the code 'R1'), but also more specific monitoring programmes such as, for instance, monitoring of transboundary rivers and networks assigned to estimate loading of coastal areas have been included in the table.

**Table 4.1.1**: Monitoring programmes with the purpose of chemical and physical assessment of river water quality. The code of the monitoring programme refers to the country and the numbers assigned to the monitoring programme in chapter 3. Sampling frequency is the most frequent.

| Code | Sites no. | Sampling freq. | No of determinands | Comments |
|---|---|---|---|---|
| **Austria** | | | | |
| AU_R1 | 244 | 6 | 59 | Main river monitoring programme |
| AU_R2/8 | 48 | 12 | V | Transboundary rivers |
| **Belgium(Flanders)** | | | | |
| BE_R1 | 957 | 8 | 19 | Main river monitoring programme |
| **Belgium(Walloon)** | | | | |
| BE_R5 | 90 | 5 | 108 | Main river monitoring programme |
| **Germany** | | | | |
| DE_R1 | 146 | 26 | 19 | Main river monitoring programme |
| **Denmark** | | | | |
| DK_R1 | 261 | 20 | 12 | Main river monitoring programme |
| DK_R2 | 58 | 4 | 8 | Monitoring of springs |
| DK_R3 | 15 | 26 | 11 | Monitoring of small stream catchments |
| **Spain** | | | | |
| ES_R1 | 448 | 9 | 42 | Main river monitoring programme |
| **Finland** | | | | |
| FI_R1 | 68 | 4 | 41 | Main river monitoring programme |
| FI_R2 | 15 | 15-70 | 18-26 | Monitoring of small drainage basins |
| FI_R3 | 30 | 12 | 41 | Monitoring of riverine loading to coastal areas |
| FI_R4 | 12 | 6-12 | 21-41 | Transboundary rivers |
| **France** | | | | |
| FR_R1 | 1082 | 12 | 40 | Main river monitoring programme |
| **Greece** | | | | |
| GR_R1 | 6 | 12 | 26 | |

| | | | | |
|---|---|---|---|---|
| GR_R2 | X | X | 17 | |
| **Ireland** | | | | |
| IE_R1 | 1500 | 12 | 18 | Main river monitoring programme |
| **Luxembourg** | | | | |
| LU_R1 | 217 | 1-13 | 20-25 | Main river monitoring programme |
| **The Netherlands** | | | | |
| NL_R1 | 26 | 13-52 | 120 | Main river monitoring programme |
| **Norway** | | | | |
| NO_R1 | 10 | 12 | 14 | Ten largest rivers |
| NO_R2 | 20 | 12 | 12 | Monitoring of acidification |
| NO_R3/6 | 25 | 12-24 | 5-22 | Monitoring of specific rivers |
| **Portugal** | | | | |
| PT_R1 | 109 | 12 | 24 | Main river monitoring programme |
| **Sweden** | | | | |
| SE_R1 | 300 | 1/5 | 25 | Main river monitoring programme |
| SE_R2 | 35 | 1 | 23 | Monitoring of small stream catchments |
| SE_R3 | 15 | 12 | 25 | Monitoring of small stream catchments |
| SE_R4 | 49 | 12 | 31 | Monitoring of riverine loading to coastal areas |
| **United Kingdom** | | | | |
| UK_R1 | 230 | 6-52 | -80 | Main river monitoring programme |
| UK_R2 | ~10,000 | 12 | 4 | Main river monitoring programme |
| **International networks** | | | | |
| **Exchange of information** | | | | |
| EU_R1 | 127 | 12 | 17 | Large rivers in EU Member States |
| **Rhine** | | | | |
| R_R1 | 10 | 26 | 60 | |

X: no specific information, V: varying, C: continuous.

**River monitoring networks**

The river monitoring networks can be divided into three categories according to their main purpose:

- (1) general characterization of rivers and streams in a country,
- (2) monitoring of water quality of rivers draining specific areas such as, for instance, reference sites in forested or uncultivated areas, or leaching of substances from agricultural watersheds, and
- (3) networks designed to estimate the riverine loading from land into coastal areas, or the loading by transboundary rivers from one country to the neighbouring country.

Many monitoring networks are multi-purpose and may be assigned to more than one category. The results from a network may, for instance, be used both to make a general characterization of river water quality and to estimate the nutrient loading of coastal areas. In Table 4.1.2 the various monitoring networks have been categorized according to their main purposes:

**Table 4.1.2:** Characterization of chemical and physical river water quality monitoring networks according to their purpose. Code refers to country plus programme number (see Table 1.2 for country code and chapter 3 for programme number).

| Country | General characterization of rivers and streams in a country (1) | Monitoring of water quality of rivers draining specific areas (reference, acidification, agricultural land) (2) | Networks designed to estimate the riverine loading to coastal areas or loading by transboundary rivers (3) |
|---|---|---|---|
| Austria | AU-R1 | | AU-R2 .. AU_R8 |
| Belgium | BE-R1/R5 | | |
| Germany | DE-R1 | | |
| Denmark | DK-R1 | DK-R1/DK-R2/DK-R3 | DK-R1 |
| Spain | ES-R1 | | |
| Finland | FI-R1 | FI_R1 | FI-R3/FI-R4 |
| France | FR-R1 | | FR-R1 |
| Greece | GR-R1/GR-R2 | | GR-R1 |
| Ireland | IE-R1 | | IE-R1 |
| Luxembourg | LU-R1 | | |
| The Netherlands | NL-R1 | | NL-R1 |
| Norway | NO-R1/NO-R2 | NO-R2 | NO-R1 |
| Portugal | PT-R1 | | |
| Sweden | SE-R1/SE-R4 | SE-R2/SE-R3 | SE-R4 |
| United Kingdom | UK-R1/UK-R2 | | UK-R1 |
| International | EU-R1 | | |

| | | | |
|---|---|---|---|
| networks | | | R-R1 |

*General characterization of river water quality*
Twenty monitoring programmes have networks specifically designed to elaborate a general characterization of rivers and streams in a country. Most of these networks are based on more than 100 sampling sites located in all major river systems and rivers in a country (Table 4.1.3). The area density of sampling sites varies from one sampling site per 10,000 $km^2$ to more than five sampling sites per 1,000 $km^2$; 1-2 sampling sites per 2,000 $km^2$ sites generally being found. The number of sampling sites per million inhabitants vary between 2 and 50. In many of the monitoring networks (eg. the British UK-R2), several sampling sites are located along the main course of the major rivers. In the Spanish network (ES-R1) around 10 sampling sites are situated along the main course of the eight major rivers, while only one sampling site is found at less important rivers. In the Danish (DK-R1) and the British network (UK-R1) there is only one sampling per river.

**Table 4.1.3:** National river monitoring programmes for general chemical and physical assessment of river water quality. "Rivers" is the total number of named rivers sampled. "River systems" is rivers discharging from the country either into coastal areas or into neighbouring countries.

| Country | Code | Sampling sites | | Rivers | River systems | Sampling frequency |
|---|---|---|---|---|---|---|
| **Austria** AU-R1 | 244 | 84 | 2 | | 6 | |
| **Belgium(Flanders)** | BE-R1 | 957 | - | - | | 8 |
| **Belgium(Walloon)** | BE-R5 | 90 | - | - | | 8 |
| **Denmark** | DK-R1 | 262 | 243 | 124 | | 12-52/20 |
| **Finland** FI-R1 | 68 | 64 | 39 | | 6-12 | |
| **France** FR-R1 | 1082 | - | - | | 12 | |
| **Germany** | DE-R1 | 146 | 84 | 15 | | 4-C/26 |
| **Greece** GR-R1 | - | | - | 6 | | 12 |
| **Ireland** IE-R1 | 1500 | 300 | 75 | | 12 | |
| **Luxembourg** | LU-R1 | 217 | 21 | 3 | | 1-13 |
| **The Netherlands** NL-R1 | 26 | - | 3 | | 6-C | |
| **Norway** NO-R1 | 10 | 10 | 10 | | 12 | |
| | NO-R2 | 20 | | | | 12 |
| **Portugal** | PT-R1 | 109 | - | 24 | | 12 |
| **Sweden** SE-R1 | 300 | - | - | | 0.2 | |
| | SE-R4 | 49 | 49 | 49 | | 12 |
| **Spain** | ES-R1 | 448 | 226 | 55 | | 1-12/9 |
| **United Kingdom** UK-R1 | 230 | ~230 | ~230 | | 6-52 | |
| | UK-R2 | 10000 | - | - | | 12 |
| **Exchange of information** | EU-R1 | 126 | 68 | 68 | 12 | |

C: Continuous measurements

According to most of these programmes, samples are taken annually with a sampling frequency ranging from 4 to 26 annual samples. The number of variables measured vary from 4 to 120, but all programmes generally include determination of basic variables (eg. pH, conductivity, water temperature, etc.), organic pollution indicators (eg. dissolved oxygen, BOD, etc.), nutrients and suspended solids. Many programmes also include determination of specific ions (eg. chloride, sulphate, calcium, etc.) and heavy metals. Additionally, determination of more specific contaminants such as organic micropollutants and radionuclides is included in some monitoring programmes.

*Monitoring of small catchments*
In the Nordic countries, ie. Denmark, Finland, Norway and Sweden, there are monitoring networks with the purpose of monitoring water quality and loading from specific catchments. These monitoring networks generally consist of up to 20 relatively small stream catchments and involve detailed integrated studies of both river water quality and of the catchment (eg. land use, soil type, etc.). The main purposes are to follow reference areas, loading from agricultural land or impact of acid precipitation.

*Riverine loading to coastal areas or loading by transboundary rivers*
Many monitoring networks are established with the purpose of estimating the riverine loading from land areas into coastal areas or loading by transboundary rivers. Generally these networks consist of sampling sites located downstream all major river systems. Countries having a long coastline compared to their area, examples being the United Kingdom, Ireland, Norway, Sweden,

Denmark and Greece, generally have a large number of relatively small river systems. Consequently, the number of sampling sites needed to estimate the input to coastal areas is high, whereas few sampling sites in countries dominated by a few large river systems provide a fair estimate of the riverine loading to coastal areas. In Denmark, for instance, sampling undertaken in 124 rivers systems only results in direct measurement of the loading from around 60 per cent of the land area into coastal areas, while sampling undertaken downstream the eight largest Spanish rivers includes approximately 75 per cent of the loading from the Spanish land area. The analysis programmes generally include determination of nutrients and suspended matter. Additionally, loading by heavy metals and organic micropollutants may be measured. The sampling frequency is typically monthly or even more frequently.

**Variables measured**

In total more than 150 different variables are measured in the various monitoring programmes. In the following evaluation of similarities and differences between the monitoring programmes attention has been directed at the most frequently measured variables.

The number of variables measured in the various monitoring programmes vary from 4 to 120 variables (Table 4.1.4). In 70 per cent of the monitoring programmes less than 40 variables are measured.

**Table 4.1.4:** Typical number of variables measured in number of river monitoring programmes and (percentage). Total 30 river monitoring programmes.

| Number of variables | 1-9 | 10-19 | 20-29 | 30-39 | 40-49 | 50- |
|---|---|---|---|---|---|---|
| No. of pro-grammes (percentage) | 2 (7) | 10 (33) | 7 (23) | 2 (7) | 4 (13) | 5 (17) |

The chemical and physical variables measured in river water have been categorized according to the information obtained on the basis of the variables determined (Table 4.1.5).

**Table 4.1.5:** Main groups to which the analytical variables have been assigned. Mnemonic codes used in report are given in parenthesis. Only the main variables are shown.

| **Basic variables** | **Suspended particulate matter** | **Organic pollution indicators** | **Eutrophication - nutrients** |
|---|---|---|---|
| water flow (Q);<br>water temperature (TEMPW);<br>pH (PH);<br>conductivity (COND);<br>dissolved oxygen (OX);<br>colour (CNR);<br>turbidity (TURB); | suspended matter (SM);<br>turbidity (TURB);<br>Biological Oxygen Demand (BOD);<br>Chemical Oxygen Demand (COD);<br>Total Organic Carbon (TOC) | dissolved oxygen (OX);<br>Biological Oxygen Demand (BOD);<br>Chemical Oxygen Demand (COD);<br>Total Organic Carbon (TOC);<br>ammoniacal nitrogen (NH4N); | total phosphorus (PTOT);<br>dissolved reactive phosphate (PO4P);<br>total or Kjeldahl nitrogen (NTOT);<br>oxidized nitrogen (NO23N);<br>nitrite nitrogen (NO2N);<br>ammoniacal nitrogen (NH4N);<br><br>chlorophyll a (CHLA);<br>Secchi disc transparency (SDT); |
| **Major specific ions** | **Metals** | **Indicators of acidification** | **Organic micropollutants** |
| chloride (CL);<br>sulphate (SO4);<br>bicarbonate (HCO3);<br>carbonate (CO3);<br>sodium (NA);<br>potassium (K);<br>calcium (CA);<br>magnesium (MG);<br>silica (SIO2);<br>arsenic (AS);<br>cyanide (CN); | aluminium (AL);<br>cadmium (CD);<br>chromium (CR);<br>copper (CU);<br>iron (FE);<br>mercury (HG);<br>manganese (MN);<br>nickel (NI);<br>lead (PB);<br>zinc (ZN); | SEE SECTION 4.4<br>pH (PH);<br>alkalinity (ALK);<br>conductivity (COND);<br>Total Organic Carbon (TOC);<br>nitrate (NO3N);<br>the 4 major cations (CA, K, MG, NA) & the anions (CL, SO4)<br>aluminium fractions (AL-frac.) | SEE SECTION 4.6<br>main groups<br>- solvents<br>- PAH<br>- PCB<br>- chlorophenols<br>- organo-Cl-pesticides |
| **Radionuclides** | **Microbiological indicators** | **Biological indicators** | |
| SEE SECTION 4.6<br>Total alpha activity<br><br>$^{137}Cs$ | SEE SECTION 4.6<br>total coliform bacteria (COLITOT);<br>faecal coliform bacteria (COLIFAEC);<br>faecal streptococci bacteria (STR_FAEC)<br>Salmonella (SALMONEL) | macroinvertebrates (INVERT)<br>zoobenthos (INVERT)<br>phytobenthos (PHYTBEN)<br>phytoplankton (PHYTPL)<br>zooplankton (ZOOPL)<br>macrophytes (MPHYT)<br>fish (FISH) | |

| | | | |
|---|---|---|---|
| | | | |

In the following sections, the various categories of variables measured are evaluated.

## Basic variables

In nearly all of the monitoring programmes basic physical and chemical variables, such as water flow (Q), water temperature (TEMPW), pH (PH), conductivity (COND), and dissolved oxygen (OX), are measured (Table 4.1.6). Additionally, some monitoring programmes include measurement of turbidity (TURB) and colour (CNR) as well. The four most frequently measured variables, ie. TEMPW, PH, COND and OX, are all included in 20 of the monitoring programmes (ie. 65 per cent). The sampling frequency of these basic variables varies from continuous registration of TEMPW, PH, COND and OX in the Rhine and continuous registration of water height (water flow) in many programmes to, typically, monthly or more frequent measurements in the majority of the other programmes.

**Table 4.1.6:** Basic variables determined in river chemical and physical water quality monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country CODE | Q | TEMPW | PH | COND | OX | TURB | CNR |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| AU-R1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| AU-R2_R8 | 12 | 12 | 12 | 12 | 12 | (12) | (12) |
| **Belgium** | | | | | | | |
| BE-R1 | . | 8 | 8 | 8 | 8 | . | . |
| BE-R5 | . | 5 | 5 | 5 | 5 | 5 | . |
| **Germany** | | | | | | | |
| DE-R1 | . | 4-52/C | 4-52/C | 4-52/C | 4-52/C | . | . |
| **Denmark** | | | | | | | |
| DK-R1 | C | 20 | 20 | . | . | . | . |
| DK-R2 | 4 | 4 | 4 | . | . | . | . |
| DK-R3 | C | 26 | 26 | . | . | . | . |
| **Spain** | | | | | | | |
| ES-R1 | 12 | 12 | 12 | 12 | 12 | . | . |
| **Finland** | | | | | | | |
| FI-R1 | . | 4 | 4 | 4 | 4 | 4 | 4 |
| FI-R2 | C | 15 | 15-70 | 15-70 | . | 15-70 | 15-50 |
| FI-R3 | . | 12 | 12 | 12 | 12 | 12 | 12 |
| FI-R4 | 12 | 12 | 12 | 12 | 12 | . | 12 |
| **France** | | | | | | | |
| FR-R1 | 12 | 12 | 12 | 12 | 12 | . | . |
| **Greece** | | | | | | | |
| GR-R1 | 12 | 12 | 12 | 12 | 12 | 12 | . |
| GR-R2 | X | X | X | X | X | X | . |
| **Ireland** | | | | | | | |
| IE-R1 | C | 12 | 12 | 12 | 12 | . | . |
| **Luxembourg** | | | | | | | |
| LU-R1 | . | 13 | 13 | 13 | 13 | . | . |
| **The Netherlands** | | | | | | | |
| NL-R1 | C | 13-52 | 13 | 13-52 | 13-52 | 13-52 | 13-52 |
| **Norway** | | | | | | | |
| NO-R1 | . | . | . | 12 | . | . | . |
| NO-R2 | 12 | . | 12 | 12 | . | . | . |
| NO-R3_R6 | . | . | 12 | 12 | . | 12 | 12 |
| **Portugal** | | | | | | | |
| PT-R1 | . | 12 | 12 | 12 | 12 | . | . |
| **Sweden** | | | | | | | |
| SE-R1 | . | 0.2 | 0.2 | 0.2 | . | . | . |
| SE-R2 | . | 1 | 1 | 1 | . | . | . |
| SE-R3 | . | 12 | 12 | 12 | . | . | . |
| SE-R4 | C | 12 | 12 | 12 | 12 | . | . |
| **United Kingdom** | | | | | | | |
| UK-R1 | . | X | X | X | X | . | . |
| UK-R2 | . | 12 | 12 | . | 12 | . | . |
| **International networks** | | | | | | | |
| **Exchange of Information** | | | | | | | |
| EU-R1 | 12 | 12 | 12 | 12 | 12 | . | . |
| **The Rhine** | | | | | | | |
| R-1 | C | C | C | C | C | . | . |
| **Total** | | | | | | | |
| M. programmes | 17 | 28 | 30 | 27 | 21 | 10 | 8 |
| Countries | 10 | 14 | 15 | 14 | 13 | 6 | 4 |

C: Continuous registration; X: Unknown or varying sampling frequency.

## Suspended particulate matter

Summary variables characterizing the content of suspended particulate matter are measured in most of the river monitoring programmes either as suspended particulate matter (SM), turbidity (TURB), biochemical oxygen demand (BOD), chemical oxygen demand (COD) or total organic carbon (TOC). The analysis programmes generally include more than one of these variables, but the variables omitted differ. SM, BOD, and COD are measured in 10-12 of the 15 countries; SM is not measured in Germany, Denmark and Ireland; BOD is not measured in Norway, Sweden and Greece; and COD is not measured in Germany, Ireland, Luxembourg, the UK and Sweden. The sampling frequency of these variables exceeds six annual samples in nearly all monitoring programmes, and samples are typically taken at monthly intervals.

**Table 4.1.7:** Suspended particulate matter measured in river chemical and physical water quality monitoring programmes. Dissolved organic carbon (DOC) has also been included in the table.

| Country CODE | SM | TURB | BOD | COD | TOC | DOC |
|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| AU-R1 | 6 | 6 | 6 | 6 | 6 | 6 | |
| AU-R2_R8 | 12 | (12) | 12 | 12 | 12 | 12 | |
| **Belgium** | | | | | | | |
| BE-R1 | 8 | . | 8 | 8 | . | . | |
| BE-R5 | 5 | 5 | 5 | 5 | . | 5 | |
| **Germany** | | | | | | | |
| DE-R1 | . | . | 4-52 | . | . | 4-52 | |
| **Denmark** | | | | | | | |
| DK-R1 | . | . | 20 | 20 | . | . | |
| DK-R3 | . | . | 26 | 26 | . | . | |
| **Spain** | | | | | | | |
| ES-R1 | 12 | . | 12 | 12 | . | . | |
| **Finland** | | | | | | | |
| FI-R1 | 4 | 4 | . | 4 | 4 | . | |
| FI-R2 | 15-70 | 15-70 | . | 15-50 | 15 | . | |
| FI-R3 | 12 | 12 | . | 12 | 12 | 12 | |
| FI-R4 | 12 | 12 | 12 | 12 | . | . | |
| **France** | | | | | | | |
| FR-R1 | 12 | . | 12 | 12 | 12 | . | |
| **Greece** | | | | | | | |
| GR-R1 | . | 12 | . | 12 | 12 | . | |
| GR-R2 | X | X | . | X | X | . | |
| **Ireland** | | | | | | | |
| IE-R1 | . | . | 12 | . | . | . | |
| **Luxembourg** | | | | | | | |
| LU-R1 | 12 | . | 12 | . | . | . | |
| **The Netherlands** | | | | | | | |
| NL-R1 | 13 | . | 13* | 13* | 13-52 | 13-52 | |
| **Norway** | | | | | | | |
| NO-R1 | 12 | . | . | . | . | . | |
| NO-R2 | . | . | . | . | 12 | . | |
| NO-R3 | . | 12 | . | (12) | (24) | . | |
| **Portugal** | | | | | | | |
| PT-R1 | 12 | . | 12 | 12 | . | . | |
| **Sweden** | | | | | | | |
| SE-R2 | . | . | . | . | 1 | . | |
| SE-R3 | . | . | . | . | 12 | . | |
| SE-R4 | 12 | . | . | . | 12 | . | |
| **United Kingdom** | | | | | | | |
| UK-R1 | X | . | X | . | . | X | |
| UK-R2 | . | . | 12 | . | . | . | |
| **International networks** | | | | | | | |
| **Exchange of Information** | | | | | | | |
| EU-R1 | . | . | 12 | 12 | . | . | |
| **The Rhine** | | | | | | | |
| R-1 | . | . | 26 | 26 | 26 | . | |
| **Total** | | | | | | | |
| M. programmes | 17 | 10 | 18 | 19 | 15 | 7 | |
| Countries | 12 | 5 | 12 | 10 | 7 | 6 | |

* Only at 2 sites

## Organic pollution indicators

There is a long tradition for measurement of organic pollution indicators in many European countries, indicators of organic pollution being included in more than 80 per cent of the river monitoring programmes. Generally, the monitoring programmes include dissolved oxygen (OX), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and ammoniacal nitrogen (NH4N). Denmark, Norway and Sweden do not measure dissolved oxygen. In some countries either BOD or COD is measured; traditionally the Nordic countries have only measured COD, while only BOD has been measured in the UK and Ireland. Especially as to BOD many different analytical methods are used. The sampling frequency is generally monthly.

**Table 4.1.8** : Organic pollution indicators determined in river chemical and physical water quality monitoring programmes. For each monitoring programme the number of annual samples are listed.

| **Country** **CODE** | **OX** | **BOD** | **COD** | **TOC** | **DOC** | **NH4N** |
|---|---|---|---|---|---|---|
| **Austria** | | | | | | |
| AU-R1 | 6 | 6 | 6 | 6 | 6 | 6 |
| AU-R2_R8 | 12 | 12 | 12 | 12 | 12 | 12 |
| **Belgium** | | | | | | |
| BE-R1 | 8 | 8 | 8 | . | . | 8 |
| BE-R5 | 5 | 5 | 5 | . | 5 | 5 |
| **Germany** | | | | | | |
| DE-R1 | 4-52/C | 4-52 | . | . | 4-52 | 4-52 |
| **Denmark** | | | | | | |
| DK-R1 | . | 20 | 20 | . | . | 20 |
| DK-R3 | . | 26 | 26 | . | . | 26 |
| **Spain** | | | | | | |
| ES-R1 | 12 | 12 | 12 | . | . | 6 |
| **Finland** | | | | | | |
| FI-R1 | 4 | . | 4 | 4 | . | 4 |
| FI-R2 | . | . | 15-50 | 15 | . | 15-70 |
| FI-R3 | 12 | . | 12 | 12 | 12 | 12 |
| FI-R4 | 12 | 12 | 12 | . | . | 4 |
| **France** | | | | | | |
| FR-R1 | 12 | 12 | 12 | 12 | . | 12 |
| **Greece** | | | | | | |
| GR-R1 | 12 | . | 12 | 12 | . | 12 |
| GR-R2 | X | . | X | X | . | X |
| **Ireland** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| IE-R1 | 12 | 12 | . | . | . | 12 |
| **Luxembourg** | | | | | | |
| LU-R1 | 12 | 12 | . | . | . | 12 |
| **The Netherlands** | | | | | | |
| IE-R1 | 13 | 13* | 13* | 13-52 | 13-52 | 13 |
| **Norway** | | | | | | |
| NO-R1 | . | . | . | . | . | 12 |
| NO-R2 | . | . | . | 12 | . | . |
| NO-R3_R6 | . | . | 12 | 24 | . | 24 |
| **Portugal** | | | | | | |
| PT-R1 | 12 | 12 | 12 | . | . | 12 |
| **Sweden** | | | | | | |
| SE-R1 | . | . | . | . | . | 0.2 |
| SE-R2 | . | . | . | 1 | . | 1 |
| SE-R3 | . | . | . | 12 | . | 12 |
| SE-R4 | 12 | . | . | 12 | . | 12 |
| **United Kingdom** | | | | | | |
| UK-R1 | X | X | . | . | X | X |
| UK-R2 | 12 | 12 | . | . | . | 12 |
| **International networks** | | | | | | |
| **Exchange of Information** | | | | | | |
| EU-R1 | 12 | 12 | 12 | . | . | 12 |
| **The Rhine** | | | | | | |
| R-1 | K | 26 | 26 | 26 | . | 26 |
| **Total** | | | | | | |
| M. programme | | 21 | 18 | 19 | 15 | 7 | 29 |
| Country | | 13 | 12 | 10 | 7 | 6 | 15 |

* Only at 2 sites

## Eutrophication - Nutrients

Eutrophication is a wide-spread problem and measurement of nutrients have therefore been included in many river monitoring programmes. Most programmes include measurement of both phosphorus and nitrogen. Total phosphorus (PTOT) is measured in 27 of the monitoring programmes, while dissolved reactive phosphate (PO4P) is measured in 28 programmes. Total and Kjeldahl nitrogen (NTOT) are measured in 15 of the monitoring programmes, while oxidized nitrogen (NO23N), mainly nitrate, and ammoniacal nitrogen are measured in 30 and 29 of the monitoring programmes, respectively. In all 15 countries PO4P, NO23N and NH4N are measured, while PTOT and NTOT are measured in 13 and 7 countries, respectively. measurement of nutrients is generally undertaken at monthly intervals.

**Table 4.1.9:** Nutrients determined in river chemical and physical water quality monitoring programmes. For each monitoring programme the number of annual samples are listed.

| **Country** **CODE** | **PTOT** | **PO4P** | **NTOT** | **NO23N** | **NO2N** | **NH4N** |
|---|---|---|---|---|---|---|
| **Austria** | | | | | | |
| AU-R1 | 6 | 6 | . | 6 | 6 | 6 |
| AU-R2_R8 | 12 | 12 | . | 12 | 12 | 12 |
| **Belgium** | | | | | | |
| BE-R1 | 8 | 8 | 8 | 8 | . | 8 |
| BE-R5 | 5 | 5 | . | 5 | 5 | 5 |
| **Germany** | | | | | | |
| DE-R1 | 4-52 | 4-52 | . | 4-52 | . | 4-52 |
| **Denmark** | | | | | | |
| DK-R1 | 20 | 20 | 20 | 20 | . | 20 |
| DK-R2 | 4 | 4 | . | 4 | . | . |
| DK-R3 | 26 | 26 | 26 | 26 | . | 26 |
| **Spain** | | | | | | |
| ES-R1 | . | 6 | . | 6 | 6 | 6 |
| **Finland** | | | | | | |
| FI-R1 | 4 | 4 | 4 | 4 | . | 4 |
| FI-R2 | 15-70 | 15-70 | 15-70 | 15-70 | . | 15-70 |
| FI-R3 | 12 | 12 | 12 | 12 | . | 12 |
| FI-R4 | 12 | 4 | 12 | 4 | . | 4 |
| **France** | | | | | | |
| FR-R1 | 12 | 12 | 12 | 12 | 12 | 12 |
| **Greece** | | | | | | |
| GR-R1 | . | 12 | . | 12 | 12 | 12 |
| GR-R2 | . | X | . | X | X | X |
| **Ireland** | | | | | | |
| IE-R1 | X | 12 | . | 12 | X | 12 |
| **Luxembourg** | | | | | | |
| LU-R1 | 12 | 12 | . | 12 | 12 | 12 |
| **The Netherlands** | | | | | | |
| NL-R1 | 13-52 | 13-52 | 13-52 | 13-52 | 13-52 | 13-52 |
| **Norway** | | | | | | |
| NO-R1 | 12 | 12 | 12 | 12 | . | 12 |
| NO-R2 | . | . | . | 12 | . | . |
| NO-R3_R6 | 12 | 12 | 12 | 12 | . | 24 |
| **Portugal** | | | | | | |
| PT-R1 | 12 | 12 | . | 12 | 12 | 12 |
| **Sweden** | | | | | | |
| SE-R1 | 0.2 | 0.2 | 0.2 | 0.2 | . | 0.2 |
| SE-R2 | 1 | 1 | 1 | 1 | . | 1 |
| SE-R3 | 12 | 12 | 12 | 12 | . | 12 |
| SE-R4 | 12 | 12 | 12 | 12 | . | 12 |
| **United Kingdom** | | | | | | |
| UK-R1 | X | X | . | X | X | X |
| UK-R2 | 12 | . | . | . | . | 12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **International networks** | | | | | | |
| **Exchange of Information** | | | | | | |
| EU-R1 | 12 | 12 | . | 12 | . | 12 |
| **The Rhine** | | | | | | |
| R-1 | 26 | 26 | . | 26 | . | 26 |
| **Total** | | | | | | |
| M.programmes | 27 | 28 | 15 | 30 | 12 | 29 |
| Countries | 13 | 15 | 7 | 15 | 10 | 15 |

* Only at 2 sites

## Specific major ions

Measurement of several specific major ions is used to characterize river water quality. The most frequently measured ions are listed in Table 4.1.10. The four major cations, ie. calcium (CA), magnesium (MG), potassium (K), sodium (NA) as well as two of the major anions, ie. chloride (CL) and sulphate (SO4), are measured in about two thirds of the monitoring programmes, while the anions carbonate (CO3) and bicarbonate (HCO3) are not included in the analysis programme. Minor halides, such as fluoride (F), bromine, iodine, and boron, are only included in a few river monitoring programmes. Additionally, only few monitoring programmes involve measurement of silica (SIO2), arsenic (AS) and cyanide (CN). The specific major ions are generally measured at monthly intervals.

**Table 4.1.10:** Specific major ions determined in river chemical and physical water quality monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country CODE | CL | SO4 | HCO3 | CO3 | SIO2 | NA | K | CA | MG | AS | F | CN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | | | | | | |
| AU-R1 | 6 | 6 | . | . | . | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| AU-R2_R6 | 12 | 12 | 12 | . | . | 12 | 12 | 12 | 12 | 6 | . | . |
| **Belgium** | | | | | | | | | | | | |
| BE-R1 | 8 | 8 | . | . | . | . | . | . | . | . | . | . |
| BE-R5 | 5 | 5 | . | . | . | . | . | . | 5 | 5 | 5 | |
| **Germany** | | | | | | | | | | | | |
| DE-R1 | 4-52 | . | . | . | . | . | . | . | . | . | . | |
| **Denmark** | not measured in national monitoring programmes | | | | | | | | | | | |
| **Spain** | | | | | | | | | | | | |
| ES-R1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 2 | 2 |
| **Finland** | | | | | | | | | | | | |
| FI-R1 | 4 | 4 | . | . | 4 | 4 | 4 | 4 | 4 | 4 | . | . |
| FI-R2 | 15-50 | 15-50 | . | . | . | 15-50 | 15-50 | 15-50 | 15-50 | 15-50 | . | 15 . |
| FI-R3 | 12 | . | . | . | 12 | 12 | 12 | 12 | 12 | 12 | . | . |
| FI-R4 | 4 | 4 | . | . | . | 12 | 4 | 4 | 4 | 4 | . | . |
| **France** | | | | | | | | | | | | |
| FR-R1 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | . | . | . |
| **Greece** | | | | | | | | | | | | |
| GR-R1 | 12 | 12 | 12 | 12 | . | 12 | . | 12 | 12 | . | . | . |
| **Ireland** | | | | | | | | | | | | |
| IE-R1 | 12 | . | . | . | X | . | . | . | . | . | . | . |
| **Luxembourg** | | | | | | | | | | | | |
| LU-R1 | 12 | 12 | . | . | . | 12 | 12 | 12 | 12 | . | . | . |
| **The Netherlands** | | | | | | | | | | | | |
| NL-R1 | 13 | 13 | . | . | . | 13* | 13* | 26* | 26* | 13* | 13* | 13* |
| **Norway** | | | | | | | | | | | | |
| NO-R2 | . | 12 | . | . | . | 12 | 12 | 12 | 12 | . | . | . |
| NO-R3_R6 | 12 | 12 | . | . | . | 12 | 12 | 12 | 12 | . | . | . |
| **Portugal** | | | | | | | | | | | | |
| PT-R1 | 12 | . | . | . | . | 12 | 12 | 12 | . | 4 | . | . |
| **Sweden** | | | | | | | | | | | | |
| SE-R1 | 0.2 | 0.2 | . | . | . | 0.2 | 0.2 | 0.2 | 0.2 | . | . | . |
| SE-R2 | 1 | 1 | . | . | 1 | 1 | 1 | 1 | 1 | . | . | . |
| SE-R3 | 12 | 12 | . | . | 12 | 12 | 12 | 12 | 12 | . | . | . |
| SE-R4 | 12 | 12 | . | . | 12 | 12 | 12 | 12 | 12 | . | . | . |
| **United Kingdom** | | | | | | | | | | | | |
| UK-R1 | X | X | . | . | X | X | X | X | X | . | . | . |
| **International networks** | | | | | | | | | | | | |
| **Exchange of information** | | | | | | | | | | | | |
| EU-R1 | 12 | . | . | . | . | . | . | . | . | . | . | . |
| **The Rhine** | | | | | | | | | | | | |
| R-1 | C | 26 | . | . | . | 26 | 26 | 26 | 26 | 26 | . | . |
| **Total** | | | | | | | | | | | | |
| M.programmes | 24 | 20 | 4 | 3 | 9 | 20 | 19 | 20 | 19 | 9 | 5 | 4 |
| Countries | 14 | 11 | 4 | 3 | 6 | 11 | 10 | 11 | 10 | 6 | 5 | 4 |

* Only at 2 sites

## Metals

Analysis of metals is performed in about 40 per cent of the river monitoring programme. However, in many of the programmes metals are only measured at selected sampling sites, primarily major rivers or rivers suspected to be contaminated by heavy metals. In two monitoring programmes (BE-R1 and GR-R2) the specific metals have not been specified. In Denmark only analysis of iron is included in national river monitoring programmes. The most frequently measured heavy metals are cadmium (CD), mercury (HG), copper (CU), zinc (ZN) and lead (PB), each measured in more than 17 of the monitoring programmes and in about 13 of the 15 countries. Aluminium (AL) is studied in countries with acidification problems. In some monitoring programmes analysis of

manganese (MN), nickel (NI) and iron (FE) is also included. The sampling frequency varies from a few annual samples to monthly samples in half of the monitoring programmes.

**Table 4.1.11:** Metals determined in river chemical and physical water quality monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country<br>CODE | AL | CR | CU | MN | NI | PB | ZN | CD | FE | HG | METALS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | | | | | |
| AU-R1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | . | . | . | . |
| AU-R2_6 | . | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | . |
| **Belgium** | | | | | | | | | | | |
| BE-R1 | . | . | . | . | . | . | . | . | . | 8 | |
| BE-R5 | . | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | . |
| **Germany** | | | | | | | | | | | |
| DE-R1 | . | 1-26 | . | . | 1-26 | 1-26 | . | 1-26 | . | 1-26 | . |
| **Denmark** | | | | | | | | | | | |
| DK-R1 | . | . | . | . | . | . | . | . | 4 | . | . |
| DK-R2 | . | . | . | . | . | . | . | . | 4 | . | . |
| **Spain** | | | | | | | | | | | |
| ES-R1 | . | 2 | 2 | 2 | . | 2 | 2 | 2 | 2 | 2 | . |
| **Finland** | | | | | | | | | | | |
| FI-R1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | . |
| FI-R2 | 15 | . | . | 15-50 | . | . | . | . | 15-50 | . | . |
| FI-R3 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | . |
| FI-R4 | . | 4 | 4 | 12 | 4 | 4 | 4 | 4 | 12 | 4 | . |
| **France** | | | | | | | | | | | |
| FR-R1 | . | X | X | . | X | X | X | X | . | X | . |
| **Greece** | | | | | | | | | | | |
| GR-R1 | . | . | 12 | 12 | . | . | 12 | 12 | . | 12 | . |
| GR-R2 | . | . | . | . | . | . | . | . | . | X | |
| **Ireland** | | | | | | | | | | | |
| IE-R1 | . | . | X | X | X | X | X | X | X | . | . |
| **Luxembourg** | | | | | | | | | | | |
| LU-R1 | . | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | . |
| **The Netherlands** | | | | | | | | | | | |
| NL-R1 | 13* | 13# | 13# | 13* | 13# | 13# | 13# | 13# | 26* | 13# | . |
| **Norway** | | | | | | | | | | | |
| NO-R1 | . | . | 12 | . | . | 12 | 12 | 12 | . | 12 | . |
| NO-R2 | 12 | . | . | . | . | . | . | . | . | . | . |
| NO-R3_6 | 12 | . | 12 | . | . | 12 | 12 | 12 | 12 | . | . |
| **Portugal** | | | | | | | | | | | |
| PT-R1 | 4 | 4 | 4 | 4 | . | 4 | 4 | 12 | 4 | 12 | . |
| **Sweden** | | | | | | | | | | | |
| SE-R1 | 0.2 | . | . | 0.2 | . | . | . | . | 0.2 | . | . |
| SE-R2 | . | . | 12 | 12 | . | 12 | 12 | 12 | 12 | 12 | . |
| **United Kingdom** | | | | | | | | | | | |
| UK-R1 | . | X | X | X | X | X | X | X | X | X | . |
| **International networks** | | | | | | | | | | | |
| **Exchange of Information** | | | | | | | | | | | |
| EU-R1 | . | . | . | . | . | . | . | 12 | . | 12 | . |
| **The Rhine** | | | | | | | | | | | |
| R-1 | . | 26 | 26 | 26 | 26 | 26 | . | 26 | 26 | 26 | . |
| **Total** | | | | | | | | | | | |
| M.programmes | 9 | 14 | 18 | 17 | 13 | 18 | 18 | 19 | 18 | 17 | 2 |
| Countries | 6 | 10 | 13 | 12 | 9 | 13 | 13 | 14 | 12 | 12 | 2 |

* Only at 2 sites; # 6-52, most often 13.

# 4.2 Biological assessment of river quality

Almost all aquatic plant or animal communities, be it micro- or macroscopic, may provide information on the quality of its environment. The community most commonly used in river quality investigations is that of the larger readily visible invertebrate animals colonizing the substrata of all rivers; such animals are collectively referred to as macroinvertebrates of which the main constituents are young aquatic stages of insects. Within this bottom dwelling community the sensitivity and tolerance to pollution of the various constituents vary considerably from species to species. Some species are, for example, very sensitive to reductions in dissolved oxygen and will not be found in areas where oxygen levels are not consistently high. A characteristic feature of polluted environments is a reduction in overall community diversity and an increase in the density of tolerant species. The composition of a macroinvertebrate community at any point in a river therefore reflects the average water quality at that particular point. For this reason macroinvertebrates are widely used in the assessment of river quality.

In the European countries there is a long tradition for assessment of river quality on the basis of macroinvertebrate studies. However, these assessments have primarily been made by local organizations responsible for managing and monitoring specific rivers. In some countries these activities have developed into national surveys of the biological quality of the main rivers (Table 4.2.1). These national surveys are generally based on the results collected by local authorities in accordance with harmonized and standardized procedures (eg. sampling methods, criteria for site selection, classification schemes, etc.). Most of the other countries do not have separate national monitoring programmes for biological assessment of river quality (Table 4.2.1). In some countries macroinvertebrate studies are, included in the general chemical river monitoring programme, macroinvertebrate investigations being, however, restricted to relatively few sampling sites.

**Table 4.2.1:** Biological assessment of river water quality

| **No** national macroinvertebrate assessment programme (or no information) | Macroinvertebrate assessment based on sampling sites included in the national chemical river monitoring programmes | Special national surveys to assess the biological quality of rivers |
|---|---|---|
| Finland<br>Greece<br>Iceland | Austria AU-R1<br>Denmark DK-R1<br>France FR-R1<br>Ireland IE-R2<br>The Netherlands NL-R1<br>Norway NO-R2<br>Sweden SE-R2/SE-R3 | Austria<br>Belgium BE-R2/R8<br>Germany DE-R2<br>Luxembourg LU-R2<br>(Portugal)<br>Spain ES-R2<br>United Kingdom UK-R3 |

**National surveys to assess the biological quality of rivers**

The specific biological monitoring surveys are usually made in connection with national classification of river quality. Austria, Germany, Luxembourg, Ireland and the United Kingdom have assessed rivers quality at two to five year intervals since the 1970s, while Belgium and Spain initiated similar activities in the 1980s. In 1992, the Netherlands added a biological subprogramme to their inland water monitoring programme MWTL and since 1989 Denmark has annually been collecting all the biological classification grades from the Danish counties. In Portugal, biological assessment (Saprobic system) is undertaken in a number of separate investigations.

**Table 4.2.2:** National river monitoring programmes based on assessment of biological river quality.

| **Code** | **Name** | **Variables** | **Period** | **Sampling frequency in year of survey** | **Geographical coverage** | **Reporting** |
|---|---|---|---|---|---|---|
| AU- | **Austria**<br>Gewässergüte der Fliessgewässer Österreichs | Saprobic system<br><br>MINVERT | Since 1968<br><br>Every two years | | Nation-wide | Report & maps every 2 year |
| BE-R2 | **Belgium**<br>Biological assessment of the quality of rivers in the Flanders region of Belgium | MINVERT<br>Belgium Biotic Index | Since 1989<br><br>Not every year | 1/yr | Flanders part of Belgium<br><br>900 sites | Report annually |
| BE-R8 | **Belgium**<br>Biological assessment of the quality of rivers in the Walloon region of Belgium | MINVERT<br>Belgium Biotic Index, Phytoplankton, Macrophytes | Since 1980<br><br>Every three years | 1/yr | Walloon region of Belgium<br><br>200+150 sites | Report & maps every 3 years |
| DK-R4 | **Denmark**<br>Inventory of biological assessment of river quality | MINVERT<br>The method and classification schemes used by Danish counties are not fully comparable | Since 1989<br>Annual collection of the results of biological classification of rivers | 1-2/yr | No standard network<br><br>Totally 10,000 sampling sites per year | Reports annually |
| DE-R2 | **Germany**<br>Water quality maps of the quality of flowing waters | Saprobic system<br><br>MINVERT<br>MiFLORA<br>MIFAUNA | Since 1976<br>Every 5 years<br><br>1976, 1980, 1985 & 1990 | | National all main flowing waters | Maps |
| IE-R2 | **Ireland**<br>Biological assessment of river quality | <br><br>MINVERT<br>MAPHYT<br>ALGAE<br>siltation | Since 1971<br>-1993 : every 4 years<br>1994- : every 3 years | 1/yr in June-September | National expanding from 2,000 km in 1971 to 7,000 km in 1981 and 12,700 km in 1990<br>approx. 3000 sites in 1200 rivers | Tables maps every 3 years |
| LU-R2 | **Luxembourg**<br>Biological assessment of river quality | Belgium Biotic Index<br><br>MINVERT and occasionally plankton and macrophytes | Since 1972<br>Every 3 to 5 years<br><br>Heavily polluted rivers are controlled every year | | National<br>Sampling are taken in the main rivers and their principal affluent especially those with fishery interests | |
| ES-R2 | **Spain**<br>Biological assessment of river quality | BMWP<br>Modified biotic index | Since 1980<br>Every 3 to 5 years | 4/yr | Nation-wide<br>847 sampling sites | Reports and maps |
| UK-R3 | **United Kingdom**<br>Biological classification of rivers and canals | MINVERT | Since the early 1970s<br>Every 5 years | Two or three annual samples | England & Wales<br>40,000 km of rivers and canals, approx. 7,000 sites<br>Scotland | Reports |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 11,000 km of rivers, 976 sampling sites Northern Ireland 2,500 km of rivers approx. 290 sites | |

MINVERT: studies of macroinvertebrate community; MiFAUNA: microfauna; MiFLORA: microflora; MAPHYT: macrophyte

The established monitoring networks generally include numerous sampling sites. The UK network and the Irish network, for instance, include around 10,000 and 3,000 sampling sites, respectively. Sites are generally located in all main rivers and reflect the full range of quality conditions of each particular river. The sampling methods used differ and sampling frequency varies among the countries (Table 4.2.2). Additional information on the various methods used for river quality classification can be found in Newman (1988), who made a more comprehensive evaluation of the different classification schemes used in the EU Member States.

In the UK and Germany local authorities, ie. the National River Authority regions and River Purification Boards in the UK, and the Länder in Germany, do the actual sampling and analysis, and special, organised task forces collect the summary results from the local organizations for national evaluation and reporting. In Ireland, by contrast, the biological assessment monitoring programme is carried out by one institution, namely the Environmental Protection Agency. The results are generally published in the form of reports including tables listing the length of rivers assigned to the various grades and river quality maps.

**Biological assessment in connection with general national river monitoring programmes**
The biological assessment in connection with general river monitoring programmes (eg. AU-R1, DK-R1, FR-R1, and SE-R2/R3) includes one or two annual investigations of macroinvertebrate communities at fixed sampling sites (Table 4.2.3). Additionally, some monitoring programmes include studies of periphyton, macrophytes and fish.

**Table 4.2.3:** Biological assessment of river quality in connection with general national river monitoring programmes.

| **Code** | **Name** | **Variables** | **Period of operation and sampling frequency (SF)** | **Geographical coverage** |
|---|---|---|---|---|
| AU-R1 | **Austria**<br>Ordinance on Water Quality Monitoring (rivers) | Saprobic index<br><br>Macroinvertebrates, Phytobenthos, | Since 1991 | Nation-wide<br>244 sampling sites |
| DK-R1 | **Denmark**<br>Nation-wide monitoring programme<br>Monitoring of streams | Macroinvertebrates<br>Phytobenthos | since 1989<br>SF: 2/yr | Nation-wide<br>261 sampling sites |
| FR-R1 | **France**<br>National basin network | Invertebrates<br>Fish | Since<br>SF: | Nation-wide<br>1082 sampling sites |
| NL-R1 | **The Netherlands**<br>National surface water monitoring programme (MWTL), biological part | Macroinvertebrates, Fish, Phytoplankton, zooplankton, macrophytes | Since 1992<br>SF: 1-13/yr, annually or in a four year cycle | Nation-wide<br>15 routine sampling sites |
| SE-R2 | **Sweden**<br>National time series reference streams | Macroinvertebrates<br>Periphyton | Since 1993<br>SF: 1/yr | 35 streams |
| SE-R3 | National intensive time series reference streams | Macroinvertebrates<br>Periphyton<br>Fish<br>Macrophytes | Since 1994<br>SF: 1/yr except macrophytes every 3 year | 15 streams |

# 4.3 Monitoring of lakes

Norway, Finland and Sweden have numerous lakes accounting for approximately 5-10 per cent of the surface area. A large number of lakes can also be found in Denmark, the northern part of Germany, Ireland and the northern and western parts of the United Kingdom. In central Europe most natural lakes are situated in mountain regions, the ones at high altitude being relatively small and the one in the valleys being the largest, examples being Lake Geneva, Lake Constance, Lake Garda and Lake Maggiore in the Alps. In addition, several lakes can be found in Austria and the northern parts of Greece. In Portugal, Spain, France, Belgium, The Netherlands, southern England, and the central parts of Germany there are generaly few natural lakes. In these areas man-made lakes such as reservoirs and ponds occur more frequently than natural lakes. In Spain, for instance, there are more than 1,000 large reservoirs.

**Chemical and physical assessment of lake water quality**
Only few countries in the EEA area have national monitoring programmes for assessment of the chemical and physical water quality of lakes. Some countries, however, undertake local monitoring of lakes, the German Federal States (Länder), for instance, monitor the environmental state of lakes in their respective areas. Local lake monitoring activities are generally not standardized at a national level, and the variables and sampling frequency vary. During the last 10-15 years some countries have made national lake inventories and collected data and elaborated reports on the general environmental state of lakes based on locally gathered information.

In the Nordic countries, in which there are many natural lakes, monitoring programmes cover a vast number of lakes. Finland, for instance, has been monitoring a wide range of lakes since the early 1960s. During the 1980s Norway and Swden have made lake surveys to assess the extent of acidification and eutrophication. Some countries have a long tradition for monitoring large nationally important lakes, Austria has by way of example monitored Lake Constance (AU-L1) and Neusiedler See since 1961 and 1972, respectively, and the Norwegian Lake Mjösa has been studied since 1971 (NO-L3). Several countries, for example the Netherlands and Portugal, do not have a specific lake monitoring programme, but include their lakes in river or inland water programmes.

In Table 4.3.1 13 general monitoring programmes aimed at chemical and physical assessment of lake water quality are listed. The main national lake monitoring programme of each country is listed first.

**Network set-up and sampling frequency**
The general national monitoring programmes can be divided into two categories. The "Survey-type" programme typically covers a great number of lakes that are sampled at long intervals. Examples of this type are NO-L2 and SE-L1, including around 100 lakes each. In Ireland a national lake survey (IE-L1) was performed in the period 1987-1990, including a total of 170 large lakes and some representative smaller lakes. Additionally, a remote sensing survey including 360 Irish lakes was performed in 1989-1990. More intensive monitoring programmes with a sampling frequency of several times a year (eg. DK-L1, SE-L3) typically cover a smaller number of lakes. Survey-type lake monitoring programmes provide a general description of the environmental state of a wide range of lakes, whereas more frequent monitoring provides information on dynamics and seasonal variation that may be used to detect trends.

**Table 4.3.1:** National lake monitoring programmes.

| Country Code | Lakes no. | Sites no. | Samp. freq. | No. of determinands |
|---|---|---|---|---|
| **Austria** | | | | |
| | no national lake monitoring programme[1] | | | |
| AU-L1 | 1 | 6 | 12 | 28 |
| AU-L2 | 1 | 1 | 1 | 27 |
| **Belgium** | | | | |
| | no information | | | |
| **Denmark** | | | | |
| DK-L1 | 37 | 40 | 19 | 20 |
| **Finland** | | | | |
| FI-L1 | | 71 | 3 | 28 |
| FI-L2 | | 71 | 0.3 | 5 |
| FI-L3 | | u.k. | 0.4 | 18 |
| FI-L4 | | 176 | 1 | 24 |
| **France** | | | | |
| | no national lake monitoring programme[2] | | | |
| **Germany** | | | | |
| | no national lake monitoring programme[3] | | | |
| **Greece** | | | | |
| | no national lake monitoring programme[4] | | | |
| **Ireland**[5] | | | | |
| IE-L1 | 170 | | Varying | 13 |
| IE-L1 | 360 | | Remote sensing | |
| **Luxembourg** | | | | |
| LU-L1 | 3 | 10 | 8 | 26 |
| **The Netherlands** | | | | |
| | no national lake monitoring programme[6] | | | |
| **Norway** | | | | |
| NO-L1 | 355 | | 4 | 21 |
| NO-L2 | 1005 | | 0.1 | 14 |
| NO-L3 | 1 | 4 | 12 | 16 |
| NO-L4 | | 50 | 1 | 21 |
| **Portugal** | | | | |
| | no national lake monitoring programme[7] | | | |
| **Spain**[8] | | | | |
| ES-L1 | 350(reservoirs) | | 4 | |

| | | | |
|---|---|---|---|
| ES-L2 | 496(reservoirs) | 4 | |
| **Sweden** | | | |
| SE-L1 | 1000 | 0.2 | 29 |
| SE-L2 | 85 | 4 | 31 |
| SE-L3 | 15 | 7 | 34 |
| **United Kingdom** | | | |
| | no national lake monitoring programme[9] | | |
| UK-L1/UK-L2[10] | | | |

[1]AU: Local monitoring of lakes. A national monitoring programme is planned. [2]FR: Local monitoring of lakes.
[3]GE: Local monitoring of lakes by Länder.
[4]GR: The inland surface monitoring programmes GR-R1 and GR-R2 include also sampling of lakes, but the number of lakes and the analysis programme is unknown.
[5]IE: Past programmes. A new programme is in preparation.
[6]NL: The inland water monitoring programme R1 includes several large lakes.
[7]PT: The inland water monitoring programme R1 includes several reservoirs.
[8]ES: The R1 river monitoring programme includes a few reservoirs.
[9]UK: Local monitoring of lakes.
[10] The purpose of the programmes is monitoring of toxic blue-green algae.

**Variables measured**

A total of 85 variables are measured in the lake monitoring programmes, but only 42 are represented in more than two programmes. In the following we will mainly consider variables present in at least three monitoring programmes. A brief overview of the main variables according to categories measured in lake monitoring programmes is presented in Table 4.3.2.

**Table 4.3.2**: Chemical and physical water quality variables measured in at least two lake monitoring programmes. Mnemonic codes are given in parenthesis.

| **Basic variables** | **Organic matter & oxygen conditions** | **Nutrients/ Eutrophication** | **Acidification** | **Specific ions** |
|---|---|---|---|---|
| water flow (Q);<br>water temperature (TEMPW);<br>pH (PH);<br>conductivity (COND);<br>dissolved oxygen (OX);<br>colour (CNR);<br>turbidity (TURB) | suspended matter (SM);<br>turbidity (TURB);<br>Biological Oxygen Demand (BOD);<br>Chemical Oxygen Demand (COD);<br>Total Organic Carbon (TOC)<br>dissolved oxygen (OX);<br>ammoniacal nitrogen (NH4N) | total phosphorus (PTOT);<br>dissolved reactive phosphate (PO4P);<br>total or Kjeldahl nitrogen (NTOT);<br>oxidized nitrogen (NO23N);<br>ammoniacal nitrogen (NH4N);<br><br>chlorophyll a (CHLA);<br>Secchi disc transparency (SDT) | See section 4.4 | chloride (CL);<br>sulphate (SO4);<br>sodium (NA);<br>potassium (K);<br>calcium (CA);<br>magnesium (MG);<br>silica (SIO2); |
| **Metals** | **Org. micropollutants** | **Microbiological** | **Biological organism** | |
| aluminium (AL);<br>cadmium (CD);<br>chromium (CR);<br>copper (CU);<br>iron (FE);<br>mercury (HG);<br>manganese (MN);<br>nickel (NI);<br>lead (PB);<br>zinc (ZN) | see section 4.6 | total coliform bacteria (COLITOT);<br>faecal coliform bacteria (COLIFAEC);<br>faecal streptococci bacteria (STR_FAEC) | macroinvertebrates (INVERT)<br>zoobenthos (INVERT)<br>phytobenthos (PHYTBEN)<br>phytoplankton (PHYTPL)<br>zooplankton (ZOOPL)<br>macrophytes (MAPHYT)<br>fish (FISH) | |

**Basic variables**

Variables describing the basic chemical and physical properties of lake water are included in most programmes (Table 4.3.3). Generally, the analysis programmes include measurement of water temperature (TEMPW), pH (PH), dissolved oxygen (OX) and conductivity (COND), whereas colour (CNR), turbidity (TURB) and absorbance (ABS) are only measured in a minority of programmes. Basic variables are missing in FI-L2/L3. These programmes are specifically concerned with biological monitoring(-L2) and monitoring of bioaccumulating compounds(-L3). Also NO-L1 (eutrophication) lacks the most essential basic variables.

**Table 4.3.3:** Basic variables measured in national lake monitoring programmes. For each monitoring programme the number of annual samples are listed.

| **Country** CODE | TEMPW | PH | COND | OX | CNR | TURB | ABS |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| AU-L1 | 12 | 12 | 12 | 12 | . | . | . |
| AU-L2 | 5 | 1 | 1 | 5 | 5 | . | . |
| **Denmark** | | | | | | | |
| DK-L1 | 19 | 19 | . | 19 | . | . | . |
| **Finland** | | | | | | | |
| FI-L1 | 3 | 3 | 3 | 3 | 3 | 3 | . |
| FI-L4 | 1 | 1 | 1 | . | 1 | 1 | . |
| **Ireland** | | | | | | | |
| IE-L1 | X | X | X | X | X | . | . |
| **Luxembourg** | | | | | | | |
| LU-L1 | 8 | 8 | 8 | 8 | 8 | 8 | . |
| **Norway** | | | | | | | |
| NO-L1 | . | . | . | . | 4 | 4 | . |
| NO-L2 | . | 0.1 | 0.1 | . | . | . | . |
| NO-L3 | 12 | 12 | 12 | . | . | . | . |
| NO-L4 | . | 1 | 1 | . | . | . | . |
| **Sweden** | | | | | | | |
| SE-L1 | 0.2 | 0.2 | 0.2 | 0.2 | . | . | 0.2 |
| SE-L2 | 4 | 4 | 4 | 4 | . | . | 4 |
| SE-L3 | 7 | 7 | 7 | 7 | . | . | 7 |

**Organic matter and oxygen conditions**

Five summary variables as indicators for the concentration of organic matter are measured in the various lake monitoring programmes: Total Organic Carbon (TOC), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), suspended particulate solids (SM) and Turbidity (TURB).

**Table 4.3.4:** Summary variables for organic matter, dissolved oxygen and ammonium measured in national lake monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country CODE | TOC | OX | BOD/COD | SM | TURB | NH4N |
|---|---|---|---|---|---|---|
| **Austria** | | | | | | |
| AU-L1 | . | 12 | . | . | . | 12 |
| AU-L2 | . | 5 | 1 | . | . | 1 |
| **Denmark** | | | | | | |
| DK-L1 | . | 19 | 19 | 19 | . | 19 |
| **Finland** | | | | | | |
| FI-L1 | 3 | . | 3 | . | 3 | 3 |
| FI-L4 | 1 | . | 1 | . | 1 | 1 |
| **Ireland** | | | | | | |
| IE-L1 | . | X | . | . | . | X |
| **Luxembourg** | | | | | | |
| LU-L1 | . | 8 | 8 | . | 8 | 8 |
| **Norway** | | | | | | |
| NO-L1 | 4 | . | . | . | 4 | . |
| NO-L2 | 0.1 | . | . | . | . | . |
| NO-L3 | 12 | . | . | . | . | . |
| NO-L4 | 1 | . | . | . | . | . |
| **Sweden** | | | | | | |
| SE-L1 | 0.2 | 0.2 | . | . | . | 0.2 |
| SE-L2 | 4 | 4 | . | . | . | 4 |
| SE-L3 | 7 | 7 | . | . | . | 7 |

**Nutrients/eutrophication**

As trophic state is an important criterion for evaluating the ecological condition of lakes, variables related hereto are commonly measured in the various lake monitoring programmes. The variables can be divided into two groups: nutrients (phosphorus and nitrogen), and variables describing the response to the trophic state (Secchi disc transparency and chlorophyll a). Nearly all the lake monitoring programmes include measurement of total phosphorus (PTOT), total nitrogen (NTOT), oxidized nitrogen (NO23N) and chlorophyll a (CHLA). Measurement of dissolved reactive phosphate (PO4P), ammonium nitrogen (NH4N) and Secchi disc transparency (SDT) is included in most of the monitoring programmes. In the lake monitoring programmes with more than one annual sample the sampling frequency of eutrophicatoin indicators varies from 3-4 annual samples in the FI-L1, NO-L1 and SE-L2 monitoring programmes to 19 annual samples in the Danish lake monitoring programme (DK-L1).

**Table 4.3.5.** Indicators of eutrophication measured in national lake monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country CODE | PTOT | PO4P | NTOT | NH4N | NO23N | SDT | CHLA |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| AU-L1 | 12 | 12 | 12 | 12 | 12 | . | 12 |
| AU-L2 | 5 | 5 | . | 1 | 5 | 5 | 5 |
| **Denmark** | | | | | | | |
| DK-L1 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| **Finland** | | | | | | | |
| FI-L1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| FI-L4 | 1 | . | 1 | 1 | 1 | . | . |
| **Ireland** | | | | | | | |
| IE-L1 | X | X | . | X | X | X | X |
| **Luxembourg** | | | | | | | |
| LU-L1 | 8 | 8 | . | 8 | 8 | 8 | . |
| **Norway** | | | | | | | |
| NO-L1 | 4 | 4 | 4 | . | 4 | 4 | 4 |
| NO-L2 | . | . | . | . | 0.1 | . | . |
| NO-L3 | 12 | . | 12 | . | 12 | 12 | 12 |
| NO-L4 | . | . | . | . | 1 | . | . |
| **Sweden** | | | | | | | |
| SE-L1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| SE-L2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SE-L3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

**Specific major ions**

Many of the lake monitoring programmes include measurement of the major cations: calcium (CA), magnesium (MG), sodium (NA) and potassium (K), and the major anions: sulphate (SO4) and chloride (CL). Silica (SiO2) is also measured in several lake monitoring programmes.

**Table 4.3.6:** Major specific ions measured in national lake monitoring programmes. For each monitoring programme the number of annual samples are listed.

| Country CODE | CA | MG | NA | K | SIO2 | SO4 | CL |
|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | |
| AU-L1 | 12 | 12 | 12 | 12 | 12 | . | 12 |
| AU-L2 | 1 | 1 | 1 | . | . | 1 | 1 |
| **Denmark** | | | | | | | |
| DK-L1 | . | . | . | . | 19 | . | . |
| **Finland** | | | | | | | |
| FI-L1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| FI-L4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Ireland** | | | | | | | |
| IE-L1 | X | X | X | X | X | X | X |
| **Luxembourg** | | | | | | | |
| LU-L1 | 8 | 8 | 8 | 8 | . | 8 | 8 |
| **Norway** | | | | | | | |
| NO-L1 | 4 | 4 | 4 | 4 | . | 4 | 4 |
| NO-L2 | 0.1 | 0.1 | 0.1 | 0.1 | . | 0.1 | 0.1 |
| NO-L3 | . | . | . | . | 12 | . | . |
| NO-L4 | 1 | 1 | 1 | 1 | . | 1 | 1 |
| **Sweden** | | | | | | | |
| SE-L1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| SE-L2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| SE-L3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

**Metals**

Up to ten metals are measured in the various national lake monitoring programmes. Some monitoring programmes include only determination of very few metals such as, for instance, iron (FE) in the Danish lake monitoring programme (DK-L1), while the Swedish and Finnish lake monitoring programmes include measurement of several metals: iron, manganese (MN), aluminium (AL), cadmium (CD), chromium (CR), copper (CU), mercury (HG), lead (PB) and zinc (ZN).

**Table 4.3.7:** Metals measured in national lake monitoring programmes. For each monitoring programme and variable the number of annual samples are listed.

| Country CODE | FE | MN | AL | CD | CR | CU | HG | PB | ZN |
|---|---|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | | | |
| AU-L1 | 12 | 12 | . | . | . | . | . | . | . |
| **Denmark** | | | | | | | | | |
| DK-L1 | 19 | . | . | . | . | . | . | . | . |
| **Finland** | | | | | | | | | |
| FI-L1 | 3 | 3 | 3 | . | . | . | . | . | . |
| FI-L3 | . | 0.4 | . | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| FI-L4 | 1 | 1 | 1 | . | . | . | . | . | . |
| **Norway** | | | | | | | | | |
| NO-L2 | . | . | 0.1 | . | . | . | . | . | . |
| NO-L4 | . | . | 1 | . | . | 1 | . | . | . |
| **Sweden** | | | | | | | | | |
| SE-L1 | 0.2 | 0.2 | 0.2 | 0.1 | . | 0.1 | 0.1 | 0.1 | 0.1 |
| SE-L2 | 4 | 4 | 4 | 4 | . | 4 | 4 | 4 | 4 |
| SE-L3 | 7 | 7 | 7 | 7 | . | 7 | 7 | 7 | 7 |

**Biological assessment of lake water quality**

Biological variables are direct indicators of environmental quality. While chemical and physical assessment measures variables decisive for environmental quality, biological assessment gives a direct description of the ecological impact. For instance, biological variables are important in the assessment of water quality with respect to eutrophication and acidification.

Biological variables are part of the sampling routine of many general lake monitoring programmes (DK-L1, NO-L1/L2, SE-L1/L2/L3) as well as programmes concerning specific localities (AU-L1/L2, NO-L3). The Finnish FI-L2 programme only includes biological variables. There are several ways of expressing biological variables. A phytoplankton community, for instance, may be expressed as a species list (qualitatively), or as biomass, biovolumes and cell counts (quantitatively). Furthermore, there may be differences in taxonomic resolution (species level, family level). Sampling and investigation of phytoplankton (PHYTPL) and zooplankton (ZOOPL) are components of several monitoring programmes. Apart from a general evaluation of the phytoplankton community, the objectives of some programmes are more specific such as assessment of the occurrence of potentially toxic blue-green algae in waterbodies used for bathing or drinking water supply (eg. UK-L1). Bottom fauna (INVERT), macrophytes (MAPHYT) and fish fauna (FISH) are also objects of study in some of the lake monitoring programmes.

**Table 4.3.8:** Biological organisms studied in national lake monitoring programmes. For each monitoring programme and variable the number of annual samples are listed.

| Country CODE | PHYTPL | ZOOPL | INVERT | MAPHYT | FISH |
|---|---|---|---|---|---|
| **Austria** | | | | | |
| AU-L1 | 12 | 12 | . | . | . |
| AU-L2 | 5 | 5 | . | 5 | . |
| **Denmark** | | | | | |
| DK-L1 | 19 | 19 | . | 1 | 0.2 |
| **Finland** | | | | | |
| FI-L2 | 0.33 | 0.33 | 0.33 | . | . |
| **Ireland** | | | | | |
| IE-L1 | X | X | . | . | . |
| **Norway** | | | | | |
| NO-L1 | 4 | 4 | . | . | 4 |
| NO-L2 | . | . | 0.1 | . | 0.1 |
| NO-L3 | 12 | 12 | 12 | . | . |
| **Sweden** | | | | | |
| SE-L1 | . | . | 0.2 | . | . |
| SE-L2 | 1 | . | 1 | . | . |
| SE-L3 | 6 | 1 | 1 | 0.3 | 1 |

**Measurement of specific constituents of sediment and biota**
In addition to monitoring of lake water quality and ecological state it may be relevant to examine the concentrations of various elements in sediment or living organisms, especially when dealing with pollution variables such as heavy metals and organic micropollutants, but also when dealing with eutrophication problems data on sediment nutrient contents is important. The most commonly measured metals are mercury, cadmium, lead, chromium, copper, nickel and zinc.

The following monitoring programmes include analyses of substances in sediment or biota:
DK-L1: Nutrients in sediment (every 5th year).
FI-L3: Metals and organic micropollutants in sediment, fish and clams.
NO-L4: Metals in sediment (yearly).
NO-L5: Survey of metals in sediment and mercury in fish (1986-1991).
SE-L2: Metals and nutrients in sediment (every 10th yr).
Mercury in fish (every 3rd yr).

# 4.4 Monitoring of surface water acidification

Acidification of surface waters is found in areas where acidic deposition is high and the catchment soil and bedrock are poor in limestone and other easily weatherable minerals. During the last century, acidic deposition in Europe has increased markedly as a consequence of increased atmospheric emission of oxides of sulphur and nitrogen, in particular from the burning of fossil fuels. The southern parts of Finland, Sweden and Norway are the areas most affected by surface water acidification. Most surface waters in western and central Europe are not affected by acidification. However, acidification has been observed in a number of areas, including high altitude lakes in some mountain regions, lakes and streams in some forest areas in central Europe, surface waters in acidic soil areas of Scotland, northern England and Wales and small seepage lakes in north-western Europe.

Monitoring of acidification effects is coordinated internationally in an ECE programme, the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes, arising from the Convention on Long-range Transboundary Air Pollution. Participants are 12 European countries, Canada and USA. The member countries report chemical and biological variables to the programme centre.

The national acidification monitoring programmes are restricted to the countries affected by surface water acidification (Table 4.4.1 & 4.4.2). Finland, Norway and Sweden have, for instance, a long tradition of assessment of surface water acidification. The

acidification monitoring programmes can be divided into: (1) nation-wide surveys to assess the extent of acidification and (2) monitoring programmes involving detailed studies of a few catchments with the purpose of understanding the process of acidification and analyzing trends. In the following the two types of monitoring programmes are described.

**National acidification surveys**

Norway, Finland and Sweden each have nation-wide surveys with the purpose of assessing the extent of acidification (NO-L2, SE-L1; Table 4.4.1). The surveys include national sampling of more than 1,000 lakes and are generally performed at intervals of five to ten years. In 1995 a coordinated lake acidification survey will be performed in each of the three countries.

The countries also take annual samples in a reduced number of lakes, ie. 176 lakes in Finland (FI-L4), 100 lakes in Norway (NO-L2) and 85 lakes in Sweden (SE-L2); in addition, a number of small streams are sampled. The annual programmes are used for analyses of acidification trends.

**Table 4.4.1:** National surface water acidification survey programmes.

| No. | Name | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage |
|---|---|---|---|---|
| **Acidification surveys** | | | | |
| FI-L4 | Acidification monitoring of surface waters | Water<br>TEMPW, COND, PH, ALK, OX, OXSAT, TURB, CNR, $COD_{MN}$, PTOT, NTOT, NO3N, NH4N, FE, MN, SIO2, K, Ca, MG, NA, SO4, CL, F, AL-fract., TOC | since 1987:<br>SF:<br>National, 1/yr<br>Lapland, 1/2-3 yr | National, 176 lakes;<br>Lapland, 200 lakes |
| NO-L2 | 1000- Lake survey | Water<br>PH, COND, CA, MG, NA, K, SO4, CL, ALK, NO3N, TOC, AL<br>Biota<br>Zoobenthos, fish | since 1986 (1005 lakes)<br>full survey approximately every 10 year<br><br>100 lakes sampled annually (1/yr) | Nation-wide survey including 1005 lakes<br><br>yearly 100 lakes, |
| NO-L4/R9 | Monitoring of acidification & heavy metals in surface waters in the Norwegian-Russian border areas | Water<br>PH, COND, CA, MG, NA, K, SO4, CL, ALK, NO3N, TOC, CU, AL, NI, PTOT, CHLA, COLIFAEC<br>Biota<br>Zoobenthos, phytoplankton, zooplankton, fish,<br>Sediment<br>CU, NI; CD, CO, PB, ZN, HG | Start year 1986<br>26 lakes and 3 rivers have been sampled since the late 1980s<br><br>lakes; 1/yr<br><br>rivers; weekly or monthly | 40-50 sampling sites in each country<br><br>In Norway:<br>26 lakes and 3 rivers plus 20 lakes only sampled twice |
| NO-L8/R13 | Monitoring the effects of acidification on fish stock in Norwegian inland waters. | Fish: species composition and abundance | since 1980<br>SF: lakes - every 2-5 years<br>rivers - 1/year | Nation-wide<br>140 river stations and 100 lake stations |
| NO-R13 | Monitoring of invertebrates in Norway.<br>To assess the development of acidification by use of indicator species | INVERT, species list, Acidification index (Raddum-index) | since 1981<br>SF: 2/year | Western Norway<br>15-20 stations in 8 river systems |
| SE-L1/R1 | National lake & stream survey<br><br>Multi-purpose monitoring programme also including assessment of acidification | Water<br>TEMPW, CL, CHLA, NH4N, NO23N, NORG, NTOT, PO4P, PRES, PTOT, COND, TOC, SIO2, SDT, ABS, PH, ANC, ALK, CA, MG, NA, K, SO4, FE, MN, AL<br>Biota<br>macroinvertebrates | since 1972;<br>SF: every five year | National - randomly selected 1000 lakes, 300 streams |
| SE-L2/R2 | National time-series in reference lakes & streams<br><br>Multi-purpose monitoring programme also including assessment of acidification. | Water<br>TEMPW, CL, CHLA, NH4N, NO23N, NORG, NTOT, PO4P, PRES, PTOT, COND, TOC, SIO2, SDT, ABS, PH, ANC, ALK, CA, MG, NA, K, SO4, FE, MN, AL<br>Biota<br>macroinvertebrates, periphyton, phytoplankton, fish paleoreconstruction<br>Sediment<br>Sediment chemistry in lakes | Some stations have time series from the 1960s, others from the 1980s and others are new.<br><br>Lake water chemistry 4/yr,<br>Stream water chemistry 12/yr,<br><br>Biota 1/yr except fish 1/3 yr and paleoreconstruction once<br><br>sediment 1/10 yr | National - 85 lakes,<br>35 streams. Subjectively selected sites representing different eco-regions, different types of lakes and streams. |

FI: Finland; NO: Norway; SE: Sweden;

One sample is taken from each waterbody both in the survey programme and in the annual programme, and it is then analyzed for general acidification variables. The common variables for all the monitoring programmes are pH (PH), conductivity (COND), alkalinity (ALK), total organic carbon (TOC), nitrate (NO3N), the four major cations: potassium (K), calcium (CA), magnesium (MG), and sodium (NA), and the anions: sulphate (SO4) and chloride (CL), and various aluminium fractions (AL-frac). Some monitoring programmes also include measurements of total phosphorus (PTOT), total nitrogen (NTOT), and ammonical nitrogen (NH4N). The extent of acidification is also assessed using of various biological indicators such as zoobenthos, phytoplankton, and fish.

**Acidification studies in specific catchments**

Seven integrated acidification monitoring programmes are in operation in five countries: Norway, Sweden, Finland, the UK, and Ireland (Table 4.4.2). Generally the programmes include extensive investigations of a limited number of waterbodies or catchments areas involving frequent sampling and determination of many variables. Chemical analyses of surface water samples are made and in some cases also of precipitation and groundwater samples. Water samples are analyzed for all the previously mentioned acidification variables. In some of the programmes detailed studies of the biological communities are also performed, examples being studies of macroinvertebrates in streams and the littoral zone of lakes, as well as studies of phytoplankton, macrophytes and fish. In some lakes the record of acidification is reconstructed by use of palaeolimnogical indicators (primarily diatoms).

**Table 4.4.2:** National surface water acidification monitoring programmes including detailed investigations of few waterbodies or catchment areas

| No. | Name | Variables | Period of operation & Sampling Frequency (SF) | Geographical coverage |
|---|---|---|---|---|
| **Monitoring of specific catchments** | | | | |
| FI-R2 | Transport of suspended & soluble material from land areas.<br><br>Multi-purpose monitoring programme also including assessment of acidification. | TEMPW, COND; PH, TURB, ALK, SM, PTOT, NTOT, NO3N, NH4N, K, CA, MG, NA, SO4, CL, TOC, CNR, $COD_{MN}$, FE, MN, AL-fract., F, | Since 1962:<br>Automatic sampling during peaks of flow, manual sampling once a week (52/yr) | 13 small watersheds |
| NO-R2 | Monitoring of 20 rivers in East, South & Western Norway<br>To provide long-term data for revealing trends in acidification | PH, COND, CA, MG, NA, K, SO4, ALK, NO3N; TOC, AL-fract., Q | since 1980<br>SF: weekly-monthly | 20 rivers in eastern, southern and western Norway |
| NO-R8 | Transport & dynamics of acid compounds in calibrated catchments | Water chemistry on surface water, groundwater, and deposition<br>PH, COND, CA, MG, NA, K, SO4, ALK, NO3N, TOC, AL, Q, | since 1973<br>SF: weekly | Nation-wide<br>5 catchments in regions with different levels of air-transported pollution of acid compounds |
| NO-L9/R12 | Monitoring of liming projects in Norway. Chemical and biological effects of liming in acidified rivers and lakes | Water: COND, TURB, PH, ALK, SO4, NO3N, NA, K, CL, AL<br>Biological: MAPHYT, INVERT, FISH | Start one year before liming is initiated. Variable sampling frequency. | Twelve liming projects, varying number of stations, but at least one reference station. |
| SE-L3/R3 | National intensive time-series in reference lakes & streams<br><br>Multi-purpose monitoring programme also including assessment of acidification. | Water<br>TEMPW, CL, CHLA, NH4N, NO23N, NORG, NTOT, PO4P, PRES, PTOT, COND, TOC, SIO2, SDT, ABS, PH, ANC, ALK, CA, MG, NA, K, SO4, FE, MN, AL, HG, CD, PB, CU, ZN<br>Biota<br>macroinvertebrates, periphyton, phytoplankton, zooplankton, fish, contaminants of fish, paleoreconstruction<br>Sediment<br>Sediment chemistry in lakes | Some stations have time series from the 1960s, other from the 1980s and some are new.<br><br>Lake water chemistry 7/yr, Stream water chemistry 12/yr,<br><br>Biota<br>Phyto- & zooplankton 6/yr macroinvertebrates, periphyton, fish, contaminants in fish 1/yr macrophytes 1/3 yr and palaeoreconstruction once<br><br>sediment 1/10 yr | Nation-wide<br>15 lakes, 15 streams<br>Subjectively selected sites representing different eco-regions, different types of lakes and streams |
| UK- | UK Acid Water Monitoring Network | Water<br>PH, ALK, COND, CA, CL, SO4, NTOT, AL_D, DOC, Q<br>Biota<br>Fish, macroinvertebrates, macrophytes, diatoms, | Since 1988<br>Water:<br>lakes 4/yr<br>streams 12/yr, and continuous registration of pH and flow in 6 streams<br>Biota<br>1/yr | 11 lakes and 11 streams in areas considered to be sensitive to acidification |
| IE- | Acid Sensitive Surface Waters in Ireland | Water chemistry on precipitation, lake water, stream water | Period 1987-90<br>Water:<br>lakes 10/yr | 5 lake catchments in acid sensitive areas<br>Sampling of lake water and 12 inflowing |

| | | | | |
|---|---|---|---|---|
| | | Water<br>OX, TEMPW, SDT, PH, COND, CNR, PO4P, NO23N, NH4N, ALK, CHLA, SO4, NA, CA, MG, CL, MN, AL-fract.<br>Biota<br>macroinvertebrates, phytoplankton, zooplankton,<br>fish, paleolimnologi studies | streams 10/yr,<br>Biota<br>2/yr | and 12 inflowing<br>streams, in addition 4 mo-untain streams were sampled.<br>An acidification survey was conducted in 129 lakes. |

FI: Finland; NO: Norway; SE: Sweden; UK: United Kingdom; IE: Ireland;

# 4.5 Monitoring of marine waters

The countries in the EEA area have a long coastline. Bordering the Barents Sea to the north, the Atlantic Ocean and the North Sea to the west and the Mediterranean to the south. In addition, Sweden, Finland, Germany and Denmark have coastlines bordering the Baltic Sea. Several semi-closed seas (eg. the Adriatic Sea, the Irish Sea and the Gulf of Bothnia) and numerous fjords, coastal and estuarine areas are located along the coast of the seventeen countries. Countries sharing marine areas usually establish some form of environmental cooperation, as is for example the case with the Baltic Sea, the North Sea, the North East Atlantic and the Mediterranean. Generally, such cooperation has resulted in the establishment of a monitoring programme covering the specific waterbody. In the EEA area the Oslo and Paris Commissions (OSPARCOM) and North Sea Task Force are responsible for the overall coordination of monitoring in the north-east Atlantic and the North Sea, while the Helsinki Commission (HELCOM) is in charge of the overall coordination of monitoring of the Baltic Sea, the monitoring of the Mediterranean being coordinated by the UNEP/MED POL programme (see also chapter 3).

The countries bordering these marine areas participate in the international monitoring programmes and the monitoring activities are incorporated into the national marine monitoring programmes. The national marine monitoring programmes are, however, generally more comprehensive including more sampling sites, especially in coastal areas, and measurement of more variables. The general purpose of national marine monitoring programmes is to assess the environmental state of the nationally important marine areas, and the national programmes are thus aimed at giving a nation-wide overview of marine environmental issues.

In this section the reported national marine monitoring programmes have been put together and a comparison of similarities and differences between the different monitoring activities has been made. In total information on approximately 38 national marine monitoring programmes from ten countries have been received (Table 4.5.1). No detailed information about marine monitoring programmes has been received from Belgium, Iceland, Italy, Portugal, and Spain. Austria and Luxembourg, of course, have no marine monitoring programmes.

The ten countries usually have one general marine monitoring programme or the general programme has been divided into sub-programmes as for example in Finland that has a coastal monitoring programme and a monitoring programme focused on open marine waters. In addition, there are some more specific monitoring programmes such as the bathing water monitoring programmes (GR-M3, UK-M5) or monitoring focused on specific biological organisms.

**Table 4.5.1:** National marine monitoring programmes in the EEA area

| **Code** | **Name** | **Variables** W: water; B: Biota; S: Sediment | **Start year and sampling frequency** | **Geographical coverage** |
|---|---|---|---|---|
| DK-M1 | Nation-wide aquatic moni-toring programme - Monitoring of coastal and open marine waters | W: C&P WQ variables<br>B: PHYTPL, ZOOPL, ZOOBEN, MAPHYT<br>S: metals, OMP | Since 1989<br>SF: Water 8-52/yr<br>Plankton 8-52/yr<br>Zoobenthos 1/yr<br>Macrophytes & sediment 1/5/yr | Nation-wide<br>200 coastal sampling sites and 80 offshore sampling sites. |
| FI-M1 | Monitoring of Finnish coastal waters | W: C&P WQ variables<br>B: PHYTPL, ZOOBEN, | Since 1964<br>SF: 1-20/yr depending on the variable | Nation-wide - coastal waters<br>12 intensive sampling sites,<br>94 other sampling sites |
| FI-M2 | Monitoring of the open sea | W: C&P WQ variables<br>B: PHYTPL, ZOOPL, ZOOBEN, | Since 1979<br>SF: daily to 4/yr depending on the variable | All main deep basins in the Gulf of Bothnia, Gulf of Finland and the Baltic Proper |
| FR-M1 | National sea water quality monitoring network - RNO | W: C&P WQ variables<br>S: metals, OMP | SF: water; 2-12/yr<br>biomass; 4/yr<br>sediment; every 2-5 yr | French coastal waters (Atlantic & Mediterranean)<br>43 areas, each composed of several sampling sites |
| FR-M2 | French seashore microbio-logical monitoring - REMI | Microbiological indicators | | 314 sampling sites in 88 areas |
| FR-M3 | French seashore phyto-plankton monitoring - | Phytoplankton | SF: 2/month, alert moni-toring on weekly basis | 37 sampling sites; |

| | | | | |
|---|---|---|---|---|
| | REPHY | | toring on weekly basis | alert programme 70-80 sites |
| DE-M1 | Bund/Länder-Messpro-gramm für die Nordsee | W: C&P WQ variables<br>S: metals, OMP | Since 1980<br>SF: 1-4/yr | 53 sampling sites in the North Sea |
| DE-M2 | Bund/Länder-Messpro-gramm für die Nordsee | W: C&P WQ variables<br>B: PHYTPL, ZOOBEN, ZOOPL | According to HELCOM guidelines | The Belt Sea and Baltic Proper |
| GR- M1 | MED POL in the Aegean and Ionian Sea and the Saronic Gulf | W: C&P WQ variables<br>B: PHYTPL, | Since 1985<br>SF: seasonally | The Aegean and Ionian Sea and the Saronic Gulf |
| GR-M2 | MED POL, Cretian marine waters | W: C&P WQ variables<br>S: metals, OMP | Since 1988<br>SF: seasonally | Cretian marine waters |
| GR-M3 | Greek bathing waters | microbiological indicators | Since 1988<br>SF: 2/month (May-October) | Greek bathing areas |
| IE-M1 | General Quality of Estuarine and Coastal Receiving Waters | W: C&P WQ variables | Since 1992<br>SF: 1-?/yr | Significant estuarine and coastal areas |
| IE-M2 | Toxic contaminant levels in the estuarine and coastal environment | W: C&P WQ variables<br>S: metals, OMP<br>B: metals, OMP | Since 1993<br>SF: 1/5-6 yr | Nation-wide. Significant estuarine and coastal areas |
| IE-M3 | Radioactivity monitoring of the Irish marine environ-ment | Radioactivity in water, sediment and biota | Since the early 1970s<br>SF: 2-4/yr | Nation-wide particularly areas affected by Sellafield |
| IE-M4 | Bathing waters | W: C&P WQ variables and microbiological indicators | Since 1979<br>SF: 1/1-2 week in summer | Nation-wide. 92 important marine bathing areas |
| IE-M5 | Bacteriological quality of shellfish waters | COLIFAEC in water and shellfish | | |
| IE-M6 | Monitoring of human food sources | W: C&P WQ variables<br>B: metals, OMP | Since 1992<br>SF: 1/yr | 18 shellfish growing areas<br>Fish landings from 5 important fishing ports |
| NL-M1 | National surface water monitoring programme Monitoring of marine wa-ters | W: C&P WQ variables<br>B: PHYTPL, ZOOBEN, MAPHYT<br>S: | Since 1972<br>SF: chemical & physical variables 1-13/yr,<br>biological variables 1-18/yr | 95 sites along the Dutch coast |

**Water (W)**: C&P WQ: chemical and physical water quality variables; **Biota (B)**, PHYTPL: phytoplankton; ZOOPL: zooplankton, PHYTBEN: phytobenthos, ZOOBEN: zoobenthos; MAPHYT: macrophytes; OMP: organic micropollutants; **Sediment (S)**, OMP: organic micropollutants. Cont./....

**Table 4.5.1 (Cont.):** National marine monitoring programmes in the EEA area

| **Code** | **Name** | **Variables** W: water; B: Biota; S: Sediment | **Start year and sampling frequency** | **Geographical coverage** |
|---|---|---|---|---|
| NO-M1 | Trend monitoring of the Norwegian coastal areas | W: C&P WQ variables<br>B: PHYTBEN, ZOOBEN | Since 1990<br>SF: 2/month | 30 sampling sites along the southern Norwegian coast |
| NO-M2 | Joint Monitoring Program-me | S: metals, OMP | Since 1980<br>SF: 1/yr | 115 sampling sites in Norwegian coastal waters |
| NO-M3 | Arctic Monitoring and Assessment (AMAP) the Barents Sea & northern fjords | S: metals, OMP | Since 1991<br>SF: 1/yr | 227 sampling sites in Barents Sea & northern Norwegian fjords |
| NO-M4 | AMAP the west coast of Novaja Zemlya | S: metals, OMP | Since 1994<br>SF: 1/yr | 30 sampling sites at the west coast and in the fjord of Novaja Zemlya |
| NO-M5/M8 | Monitoring of seven speci-fic Norwegian fjords | W: C&P WQ variables<br>Biota<br>S: metals, OMP | Since 1970s<br>SF: variable | Grenlandsfjord, Ranfjorden, Sør-fjord, Hardangerfjord, Hvaler and Singlefjord |
| SE-M1 | Nation-wide pelagical high frequency monitoring | W: C&P WQ variables<br>B: PHYTPL, ZOOPL | Since 1976<br>SF: 8-25/yr | 3 Swedish coastal and 5 offshore sampling sites |
| SE-M2 | Nation-wide pelagical frequent monitoring | W: C&P WQ variables<br>B: PHYTPL, ZOOPL | Since 1992<br>SF: 6-12/yr | 26 sampling sites |
| SE-M3 | Nation-wide pelagical low frequency monitoring | W: C&P WQ variables<br>B: PHYTPL, ZOOPL | Since 1993<br>SF: 6-12/yr FS<br>1/yr LFS | 25 sampling sites frequent samp-ling(FS), 68 sampling sites low frequent sampling (LFS) |
| SE-M4/M8 | Monitoring of biota | Zoobenthos, phytobenthos, fish | Since 1980s<br>SF: 1/yr | Swedish marine waters |
| UK-M1 | UK National Marine Moni-toring Plan | W: C&P WQ variables<br>S: metals, OMP | Data from at least 1988<br>SF: water 1-4/yr<br>biota 1-2/yr<br>sediment 1/yr | Approx. 100 sites in the upper, middle and lower reaches of estu-aries, inshore and offshore coastal sites around the UK |
| UK-M4 | Marine Algae Monitoring Programme | Marine algae | Since 1991<br>Weekly from May to Sep-tember | 640 identified and non-identified bathing waters |

| | | | | |
|---|---|---|---|---|
| UK-M5 | Monitoring of Bathing Waters | Bacteria and a few physical and organic pollution determinands. | SF: 20 samples a year during the bathing season. | 460 bathing waters in Scotland, N.Ireland and England+Wales. |
| UK-M6 | Water Quality of Shellfish Waters | Heavy metals, organic micropollutants. | SF: 2-12/year depending on variable type. | 29 shellfish waters. |

**Water (W)**: C&P WQ: chemical and physical water quality variables; **Biota (B)**, PHYTPL: phytoplankton; ZOOPL: zooplankton, PHYTBEN: phytobenthos, ZOOBEN: zoobenthos; MAPHYT: macrophytes; OMP: organic micropollutants; **Sediment (S)**, OMP: organic micropollutants.

Most of the marine monitoring programmes include monitoring of chemical and physical variables in the water column, and several also include studies of the biota (phytoplankton, zooplankton, zoobenthos, etc.). The sampling networks generally consist of a number of intensive sampling sites, typically less than 20 sites, at which frequent sampling (> 12/yr) of the water column is made supplemented with an extensive sampling network including several sampling sites and low frequency sampling (1-4/yr) of the water column. Zoobenthos and sediment samples are generally taken at numerous sampling sites.

**Variables measured on marine water samples**

Around 100 different chemical and physical variables are measured on water samples in the various marine monitoring programmes, more than half of the variables being different organic micropollutants. Only 28 variables, except for organic micropollutants, are measured in more than two marine monitoring programmes (Table 4.5.2).

**Table 4.5.2**: Chemical and physical water quality variables measured in at least three marine monitoring programmes.

| **Basic variables** | **Suspended matter** |
|---|---|
| water temperature (TEMPW)<br>salinity (SAL)<br>dissolved oxygen (OX)<br>pH (PH) | suspended matter (SM)<br>Total Organic Carbon (TOC)<br>Turbidity (TURB) |
| **Oxygen condition** | **Eutrophication - nutrients** |
| dissolved oxygen (OX)<br>hydrogen sulphide (H2S) | oxidized nitrogen (NO23N)<br>ammonium (NH4N)<br>total nitrogen (NTOT)<br>dissolved reactive phosphate (PO4P)<br>total phosphorus (PTOT)<br>silica (SIO2)<br>Secchi disc transparency (SDT)<br>chlorophyll a (CHLA)<br>primary production (BPP) |
| **Metals** | **Organic micropollutants** |
| mercury (HG)<br>cadmium (CD)<br>copper (CU)<br>lead (PB)<br>zinc (ZN)<br>chromium (CR)<br>nickel (NI)<br>iron (FE)<br>cobolt (CO)<br>manganese (MN)<br>arsenic (AS) | See section 4.6 |

**Basic variables**

Most of the marine monitoring programmes include measurements of basic variables such as water temperature (TEMPW), salinity (SAL), dissolved oxygen (OX) and pH (PH). In many monitoring programmes basic variables are measured very frequently, typically bimonthly sampling is undertaken.

**Table 4.5.3:** Basic variables measured in the water column in national marine monitoring programmes.

| Country | code | TEMPW | SAL | OX | PH | TURB | COND |
|---|---|---|---|---|---|---|---|
| **Denmark** | | | | | | | |
| | DK-M1 | 12 | 12 | 12 | 12 | . | . |
| **Finland** | | | | | | | |
| | FI-M1 | 20 | 20 | 20 | 20 | 20 | 20 |
| | FI-M2 | 4 | 4 | 4 | 4 | . | . |
| **France** | | | | | | | |
| | FR-M1 | 5 | 5 | 5 | . | . | . |
| | FR-M3 | 24 | 24 | . | . | 24 | . |
| **Germany** | | | | | | | |
| | DE-M1 | 4 | 4 | 4 | 4 | . | 4 |
| **Greece** | | | | | | | |
| | GR-M1 | 4 | 4 | 4 | . | . | . |
| **Ireland** | | | | | | | |
| | IE-M1 | X | X | X | . | . | . |
| | IE-M4 | . | . | X | X | . | . |
| | IE-M6 | X | X | X | X | . | . |
| **The Netherlands** | | | | | | | |
| | NL-M1 | 12 | 12 | 12 | 12 | 12 | . |
| **Norway** | | | | | | | |
| | NO-M1 | 24 | 24 | 24 | . | . | . |
| | NO-M5-8 | X | X | X | . | X | . |
| **Sweden** | | | | | | | |
| | SE-M1 | 25 | 25 | 25 | 25 | . | . |
| | SE-M2 | 8 | 8 | 8 | 8 | . | . |
| | SE-M3 | 10 | 10 | 10 | 10 | . | . |
| **United Kingdom** | | | | | | | |
| | UK-M1 | 1 | 1 | 1 | . | . | . |

X: unknown or varying sampling frequency

### Suspended particulate matter

Three summary variables used as indicators for the concentration of suspended matter are measured in the marine monitoring programmes: suspended matter (SM) or total organic carbon (TOC) and turbidity (TURB).

**Table 4.5.4:** Suspended matter variables measured in the water column in national marine monitoring programmes.

| Country | code | TOC | SM | TURB |
|---|---|---|---|---|
| **Denmark** | | | | |
| | DK-M1 | 12 | . | . |
| **Finland** | | | | |
| | FI-M1 | 20 | 20 | 20 |
| **France** | | | | |
| | FR-M3 | . | . | 24 |
| **Germany** | | | | |
| | DE-M1 | . | 4 | . |
| **Greece** | | | | |
| **Ireland** | | | | |
| | IE-M1 | . | . | . |
| | IE-M6 | . | X | . |
| **The Netherlands** | | | | |
| | NL-M1 | . | 12 | 12 |
| **Norway** | | | | |
| | NO-M1 | . | 24 | . |
| | NO-M5-8 | X | X | X |
| **Sweden** | | | | |
| **United Kingdom** | | | | |
| | UK-M1 | . | 1 | . |

X: unknown or varying sampling frequency

### Eutrophication - nutrients

All the ten countries have at least one national marine monitoring programme with the purpose of assessing the concentration of nutrients in the water column. As a rule the monitoring programmes include measurement of nitrogen, ie. oxidized nitrogen (NO23N), ammonium (NH4N) and total nitrogen (NTOT); phosphorus, ie. dissolved reactive phosphorus (PO4P) and total phosphorus (PTOT); and silica (SIO2). Additionally, the impact of eutrophication is measured using general indicator variables such as Secchi disc transparency (SDT), chlorophyll a (CHLA) and primary production (BPP).

**Table 4.5.5:** Nutrients and other eutrophication variables measured in the water column in national marine monitoring programmes.

| Country code | NO23N | NH4N | NTOT | PO4P | PTOT | SIO2 | SDT | BPP | CHLA |
|---|---|---|---|---|---|---|---|---|---|
| **Denmark** | | | | | | | | | |
| DK-M1 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| **Finland** | | | | | | | | | |
| FI-M1 | 20 | 20 | 20 | 20 | 20 | 20 | . | 2 | 2 |
| FI-M2 | 4 | 4 | 4 | 4 | 4 | 4 | . | 4 | 4 |
| **France** | | | | | | | | | |
| FR-M1 | 5 | 5 | . | 5 | . | 5 | . | . | 5 |
| FR-M3 | . | . | . | . | . | . | . | . | 24 |
| **Germany** | | | | | | | | | |
| DE-M1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | . | . |
| **Greece** | | | | | | | | | |
| GR-M1 | . | . | 4 | . | 4 | . | . | . | . |
| **Ireland** | | | | | | | | | |
| IE-M1 | X | X | . | X | . | X | X | . | X |
| IE-M4 | X | X | X | X | . | . | X | . | X |
| **The Netherlands** | | | | | | | | | |
| NL-M1 | 12 | 12 | . | 12 | 12 | 12 | . | . | . |
| **Norway** | | | | | | | | | |
| NO-M1 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | . | . |
| NO-M5/8 | X | X | X | X | X | X | X | . | X |
| **Sweden** | | | | | | | | | |
| SE-M1 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| SE-M2 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| SE-M3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 1 | 1 |
| **United Kingdom** | | | | | | | | | |
| UK-M1 | 1 | 1 | . | 1 | . | . | 1 | . | 1 |

X: unknown or varying sampling frequency

## Metals

Measurement of metals in the water column is also included in many of the national marine monitoring programmes. Denmark and Sweden, however, do not measure metals in the water column. Ireland measures heavy metals in a number of localised and occasional programmes. The heavy metals of mercury (HG), cadmium (CD), chromium (CR), copper (CU), lead (PB), zinc (ZN) and nickel (NI) are the most frequently included metals, while iron (FE), cobolt (CO), manganese (MN) and arsenic (AS) are only included in a few monitoring programmes. The sampling frequency varies from once every third year to 4-5 annual samples.

**Table 4.5.6:** Metals measured in the water column in national marine monitoring programmes.

| Country code | HG | CD | CU | PB | ZN | CR | NI | FE | CO | MN | AS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Finland** | | | | | | | | | | | |
| FI-M1 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | . | 20 | 0.33 | 0.33 | . |
| **France** | | | | | | | | | | | |
| FR-M1 | 5 | 5 | 5 | 5 | 5 | . | . | . | . | . | . |
| **Germany** | | | | | | | | | | | |
| DE-M1 | 4 | . | 4 | 4 | 4 | 4 | 4 | . | . | . | 4 |
| **Greece** | | | | | | | | | | | |
| GR-M2 | 3 | 3 | . | . | . | . | . | . | . | . | . |
| **The Netherlands** | | | | | | | | | | | |
| NL-M1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | . | . | . | 4 |
| **Norway** | | | | | | | | | | | |
| NO-M6 | X | X | X | X | X | X | X | X | X | X | X |
| **United Kingdom** | | | | | | | | | | | |
| UK-M1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | . | . | . | . |

X: unknown or varying sampling frequency

## Bottom sediment

Several of the marine monitoring programmes include measurement of metals associated with the bottom sediment. The most frequently measured metals are mercury (HG), cadmium (CD), copper (CU), lead (PB), nickel (NI), chromium (CR) and zinc (ZN).

**Table 4.5.8:** Metals measured on bottom sediments in national marine monitoring programmes.

| Country code | CR | CU | HG | NI | PB | ZN | CD | AL | CO | FE | LI | MN | TI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Denmark** | | | | | | | | | | | | | |
| | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Finland** | | | | | | | | | | | | | |
| | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **France** | | | | | | | | | | | | | |
| FR-M1 | . | 0.3 | 0.30 | . | 0.3 | 0.3 | 0.3 | . | . | . | . | . | . |
| **Germany** | | | | | | | | | | | | | |
| DE-M1 | 4 | 4 | 4 | 4 | 4 | 4 | . | . | . | . | . | . | . |
| **Greece** | | | | | | | | | | | | | |
| GR-M2 | . | . | 3 | . | . | 3 | . | . | . | . | . | . | . |
| **Ireland** | | | | | | | | | | | | | |
| IE-M2 | X | X | X | . | X | X | X | X | . | . | X | . | . |
| **The Netherlands** | | | | | | | | | | | | | |
| | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Norway** | | | | | | | | | | | | | |
| NO-M2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| NO-M3 | 1 | 1 | . | 1 | 1 | 1 | 1 | . | . | 1 | . | . | |

NO-M4 . 1 1 . 1 1 1 1 . . 1 . .
NO-M5/8 X X X X X X X . . X . . X
**Sweden**
. . . . . .
**United Kingdom**
UK-M1 1 1 1 1 1 1 1 . . . . . .

X: unknown or varying sampling frequency

### Measurement of metals in biota

Measurement of the concentration of metals in the tissue of various biological organisms is also included in some monitoring programmes.

**Table 4.5.8:** Metals measured on biota in national marine monitoring programmes.

| Country code | AS | CR | CU | HG | NI | PB | ZN | CD | CO | AL | FE | LI | MN | TI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Denmark** | | | | | | | | | | | | | | |
| | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Finland** | | | | | | | | | | | | | | |
| FI-M2 | . | . | . | 4 | . | 4 | . | 4 | . | . | . | . | . | . |
| **France** | | | | | | | | | | | | | | |
| FR-M1 | . | . | 4 | 4 | . | 4 | 4 | 4 | . | . | . | . | . | . |
| **Germany** | | | | | | | | | | | | | | |
| DE-M1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | . | . | . | . | . | . | . |
| **Greece** | | | | | | | | | | | | | | |
| GR-M1 | . | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | . | . | . | . | . |
| **Ireland** | | | | | | | | | | | | | | |
| IE-M2 | . | X | X | X | . | X | X | X | . | . | . | . | . | . |
| IE-M6 | . | 1 | 1 | 1 | 1 | 1 | 1 | 1 | . | . | . | . | . | . |
| **The Netherlands** | | | | | | | | | | | | | | |
| NL-M1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | . | . | . | . | . | . |
| **Norway** | | | | | | | | | | | | | | |
| NO-M2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| NO-M3 | . | . | 1 | 1 | . | 1 | 1 | 1 | . | 1 | . | 1 | . | . |
| NO-M5/8 | . | X | X | X | X | X | X | X | . | . | X | . | . | X |
| **Sweden** | | | | | | | | | | | | | | |
| | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **United Kingdom** | | | | | | | | | | | | | | |
| UK-M1 | 1 | . | . | 1 | . | 1 | 1 | 1 | . | . | . | . | . | . |

X: unknown or varying sampling frequency

### Biological assessment of the state of marine waters

Several of the marine monitoring programmes include studies of various biological organisms. Investigation of phytoplankton (PHYTPL) is the most frequent biological variable to be included. These phytoplankton investigations range from monitoring programmes focusing on toxic algae in relation to bathing or shellfish production to detailed investigations of the phytoplankton communities especially in relation to eutrophication problems. Detailed studies of phytoplankton generally also include studies of zooplankton (ZOOPL). In countries where the environmental state of marine waters has deteriorated due to frequent periods of oxygen deficit studies of the benthic invertebrate fauna (ZOOBEN) are included in the national marine monitoring programmes. In some monitoring programmes macrophytes (MAPHYT) and fish (FISH) are studied as well. In Ireland, phytoplankton and zoobenthos are monitored in a number of localised and occasional programmes.

**Table 4.5.7:** Biological organisms included in national marine monitoring programmes.

| Country code | PHYTPL | ZOOPL | PHYTBEN | ZOOBEN | MAPHYT | FISH | BIRDS | MAMMALS |
|---|---|---|---|---|---|---|---|---|
| **Denmark** | | | | | | | | |
| DK-M1 | 12 | 12 | . | 2 | 2 | . | . | . |
| **Finland** | | | | | | | | |
| FI-M1 | 2 | . | . | 2 | . | . | . | . |
| FI-M2 | 4 | 4 | . | 4 | . | . | . | . |
| **France** | | | | | | | | |
| FR-M3 | 24 | . | . | . | . | . | . | . |
| **Germany** | | | | | | | | |
| **Greece** | | | | | | | | |
| GR-M1 | 4 | . | . | . | . | . | . | . |
| **The Netherlands** | | | | | | | | |
| NL-M1 | 18 | . | . | 1 | 1 | . | 6 | 6 |
| **Norway** | | | | | | | | |
| NO-M1 | . | . | 1 | 1 | . | . | . | . |
| NO-M5/8 | . | . | X | X | X | X | . | . |
| **Sweden** | | | | | | | | |
| SE-M1 | 25 | 25 | . | . | . | . | . | . |
| SE-M2 | 8 | . | . | . | . | . | . | . |
| SE-M3 | 1 | 1 | . | . | . | . | . | . |
| SE-M4 | . | . | X | X | . | X | . | . |
| **United Kingdom** | | | | | | | | |
| UK-M2 | 20 | . | . | . | . | . | . | . |

X: unknown or varying sampling frequency

# 4.6. Organic micropollution, radioactivity and microbiology.

**Organic micropollutants.**
Organic micropollutants are a large group of potentially toxic or carcinogenic chemical subtances. Many are very persistent and/or degrade into secondary harmful compounds such as the DDT-derivatives DDD and DDE. These compounds tend to accumulate in the environment and biota, and it is therefore essential to assess the level of organic micropollutants, not only in the water but also in the sediment and in living organisms. Assessment of bio-accumulation is typically conducted on species exploited for consumption such as fish or mussels. In a few programmes analyses on suspended matter are undertaken (eg. NL-R1/M1, R-R1), and these are not distinguished from ordinary water samples.

Due to differences in land usage and agricultural practice, industrial type and wastewater treatment practice now and in the past, there are substantial differences in the organic micropollutant variables measured.

There are also differences in the level of details, some countries measuring a wide range of specific compounds, others relying on a few general analyses. For example, in some programmes PCBs are measured in total, in others as the concentration of a number of individual congeners (eg. PCB-28, PCB-58, etc.).

**Table 4.6.1.** Number of monitoring programmes measuring the most commonly occurring determinands

| Determinand | NO. PROGRAMMES |
|---|---|
| PCB | 23 |
| POLYAROMATIC HYDROCARBONS | 20 |
| GAMMA-HCH | 13 |
| DDT | 13 |
| HEXACHLOROBENZENE | 11 |
| HALOGENATED AROMATICS | 9 |
| PHENOL COMPOUNDS | 9 |
| DDE | 10 |
| ANIONIC DETERGENTS | 9 |
| ALPHA-HCH | 7 |
| DDD | 8 |
| DIELDRIN | 8 |
| ATRAZIN | 6 |
| BENZO(a)PYRENE | 6 |
| EXTRACTABLE ORGANIC HALOGENS | 5 |
| OIL | 4 |
| PENTACHLOROPHENOL | 4 |
| TRICHLOROMETHANE | 4 |

*Variables measured.*
A total of 123 variables are represented in the national monitoring programmes, but only 18 are represented in more than three programmes (Table 4.6.1). The most frequently measured compounds belong to the groups Organic solvents, Polycyclic Aromatic Hydrocarbons (PAHs), PCBs, Organo-Chloro pesticides (including DDT and its derivatives), other Halogenated compounds and Detergents.

*Monitoring programmes.*
Several monitoring programmes deal specifically with bioaccumulating compounds, ie. heavy metals and organic micropollutants (eg. FI-L3 and NO-M2/M3). Other programmes pay special, though not exclusive, attention to these substances, and many programmes include just a few variables, typically summary variables or significant pesticides. A few countries (Denmark and Sweden) do not include these substances in their national monitoring programmes.

**Table 4.6.2.** Number of determinands of various groups of compounds measured in marine and inland surface water monitoring programmes

| Country /code | Sol-vents | PAH | Chloro-PCB | Organo-Cl-phenols | Organo-Cl-pesticides | Deter-gents |
|---|---|---|---|---|---|---|
| **Austria** | | | | | | |
| AU-R1 | 6 | 1 | 1 | . | . | 3 |
| AU-R2 | . | . | . | . | 2 | 1 |
| AU-R3 | 3 | . | . | . | . | . |
| AU-R5 | . | . | . | . | 2 | 1 |
| AU-R6 | . | 1 | 1 | . | . | 1 |
| **Belgium** | | | | | | |
| BE-R5 | 8 | 15 | 9 | . | 17 | 1 |
| **Germany** | | | | | | |
| DE-M1 | . | . | 1 | . | 2 | . |
| DE-R1 | 1 | . | . | . | 1 | . |
| **Spain** | | | | | | |
| ES-R1 | . | . | . | . | . | 1 |
| **Finland** | | | | | | |
| FI-L3 | 1 | 1 | 1 | 1 | 1 | . |
| FI-M1 | 1 | 1 | 1 | 1 | 1 | . |
| FI-R4 | . | . | . | . | . | 1 |
| **France** | | | | | | |
| FR-M1 | . | 1 | 1 | . | 5 | . |
| FR-R1 | 1 | . | 1 | 1 | 3 | . |
| **Greece** | | | | | | |
| GR-M1 | . | 1 | . | . | . | . |
| GR-M2 | . | 1 | . | . | . | 1 |
| GR-R2 | . | . | . | . | . | 1 |
| **Ireland** | | | | | | |
| IE-M2 | 1 | 1 | 1 | . | 10 | . |
| IE-M6 | . | . | 1 | . | 10 | . |
| **Netherl.** | | | | | | |
| NL-M1 | . | 3 | 1 | . | 6 | . |
| NL-R1 | 13 | 12 | 7 | 3 | 17 | 1 |
| **Norway** | | | | | | |
| NO-M2 | . | 30 | 18 | . | 14 | . |
| NO-M3 | . | 1 | 1 | . | . | . |
| NO-M4 | . | 1 | 1 | . | . | . |
| NO-M5 | . | 1 | 1 | . | 1 | . |
| NO-M6 | . | 2 | 2 | . | 3 | . |
| NO-M7 | . | 1 | 1 | . | 1 | . |
| NO-M8 | . | 1 | 1 | . | 6 | . |
| NO-R1 | . | . | 1 | . | 1 | . |
| **Rhine** | | | | | | |
| R-R1 | 9 | 6 | 8 | 1 | 11 | . |
| **UK** | | | | | | |
| UK-M1 | 6 | . | 11 | 1 | 12 | . |
| UK-R1 | . | 7 | 1 | 1 | 8 | 2 |

The strategy of the countries with respect to compartments assessed and number of determinands in marine and inland surface waters is illustrated in Table 4.6.3. Amongst inland surface water programmes there is only one lake monitoring programme assessing organic micropollution (FI-L3, measuring 10 determinands), the remaining 15 being river programmes.

Germany, Spain, France and Greece analyze for relatively few substances, whereas, for instance, Norway, the UK and The Netherlands put a wide range of variables into use. The different compartments are weighed differently among the countries, Norway, for instance, concentrating on aspects of bioaccumulation reflected by detailed measurements of sediment and biota, whereas Austria mainly carries out water analyses.

**Table 4.6.3.** Number of determinands measured in water, sediment and biota in marine and inland surface water monitoring programmes.

| COUNTRY/WATERS | WATER | SEDIMENT | BIOTA |
|---|---|---|---|
| **Austria** | | | |
| Inland(R1-R3,R5-R7) | 21 | 2 | 0 |
| **Belgium** | | | |
| Inland(R5) | 55 | 0 | 0 |
| **Germany** | | | |
| Marine(M1) | 3 | 3 | 3 |
| Inland(R1) | 2 | 0 | 0 |
| **Spain** | | | |
| Inland(R1) | 2 | 0 | 0 |
| **Finland** | | | |
| Marine(M1) | 10 | 0 | 0 |
| Inland(L3,R4) | 13 | 10 | 10 |
| **France** | | | |
| Marine(M1) | 7 | 7 | 7 |
| Inland(R1) | 7 | 7 | 7 |
| **Greece** | | | |
| Marine(M1,M2) | 3 | 3 | 0 |
| Inland(R2) | 2 | 0 | 0 |
| **Ireland** | | | |
| Marine(M2,M6) | 5 | 11 | 12 |
| **Netherlands** | | | |
| Marine(M1) | 3 | 0 | 12 |
| Inland(R1) | 26 | 43 | 37 |
| **Norway** | | | |
| Marine(M2-M8) | 10 | 67 | 70 |
| Inland(R1) | 2 | 0 | 0 |
| **UK** | | | |
| Marine(M1) | 31 | 17 | 21 |
| Inland(R1) | 20 | 0 | 0 |
| **Rhine** | | | |
| Inland | 53 | 0 | 0 |

*Where to assess what?*

There is considerable difference in the persistence of various compounds. More persistent compounds tend to accumulate in food chains. Consequently, the concentration of these compounds can be much higher in living organisms and sediment than in water. Less persistent or volatile compounds, on the contrary, tend to decompose or escape before they are assimilated by organisms, and the highest concentrations are consequently measured in water. The persistence of compounds also affects the impact of pollution in different waterbodies. Thus easily degradable compounds show the highest concentrations in close vicinity to the discharge source, whereas more persistent compounds are at least as important far from the source. These differences are reflected in the variables measured in different compartments in different kinds of waterbodies as indicated by table 4.6.4. that shows the number of monitoring programmes assessing the pollution level of various groups of substances in three compartments of marine and freshwater areas.

**Table 4.6.4.** Number of monitoring programmes measuring at least one determinand within various groups of compounds

| GROUP | WATER | SEDIMENT | BIOTA |
|---|---|---|---|
| **Solvents** | | | |
| Marine | 3 | 0 | 0 |
| Inland | 8 | 2 | 2 |
| **PAH** | | | |
| Marine | 6 | 8 | 7 |
| Inland | 7 | 1 | 1 |
| **PCB** | | | |
| Marine | 5 | 10 | 11 |
| Inland | 9 | 2 | 2 |
| **Chlorophenols** | | | |
| Marine | 2 | 0 | 1 |
| Inland | 5 | 2 | 2 |
| **Cl-Pesticides** | | | |
| Marine | 6 | 6 | 10 |
| Inland | 10 | 2 | 2 |
| **Detergents** | | | |
| Marine | 1 | 1 | 0 |
| Inland | 10 | 0 | 0 |

Pollution by organic solvents, which are generally volatile but harmful before they escape, is almost exclusively assessed in the water phase and primarily in rivers, ie. close to the outlets from industry or wastewater treatment plants. The more persistent

Polycyclic Aromatic Hydrocarbons (PAH) are primarily measured in river water or in the sediment and biota of marine areas, but also to some extent in sea water. This pattern reflects assessment of the current pollution discharge as measured in water, as well as the long-term accumulation in the final stratum, the sediment and biota of the sea.

**Radioactivity determinands**
Radioactive pollution is a widespread problem in marine areas and many river systems. Even though radioactive isotopes are used for a number of purposes, nuclear power plants and fuel reprocessing facilities are by far the most important contributors to radioactive pollution. Assessment of radioactive contaminants is a standard routine in marine areas and certain river systems with monitoring more intensive in areas of greater risk, eg. a major part of the IE-M3 Irish marine monitoring programme is devoted to an assessment of the discharges from Sellafield.

Radioactive pollution is assessed by measurements of the concentrations of individual radionuclides such as tritium, caesium-137 and plutonium. Total alpha and beta/gamma activity measurements may also be made (Table 4.6.5).

Accumulation in sediment and biota is an important aspect of radioactive pollution, especially where fish or mussels are exploited for human consumption. Public health care requires assessment of exploited species. This is included in the marine monitoring programmes of Norway and Ireland, whereas the river monitoring programmes of Austria, the Netherlands and the Rhine only analyze for radioactivity in the water, ie. as solute or in suspended matter. We are aware that other countries carry out extensive studies on radioactive pollution, but we have no detailed information on these programmes.

**Table 4.6.5.** Sampling frequency of radioactivity variables.

| Country /code | Alpha tot. | Beta tot. | Beta res. | Gamma tot. | H 3 | K 40 | I 131 | Cs 134 | Cs 137 | Pb 210 | Pb/ Po | Sr/ Pu | Ra | Am |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ireland** | | | | | | | | | | | | | | |
| IE-M3 | . | . | . | . | . | . | 3 | 3 | 3 | . | . | 3 | . | 3 |
| **Norway** | | | | | | | | | | | | | | |
| NO-M2 | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . |
| NO-M3 | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . |
| NO-M4 | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . |
| **Austria** | | | | | | | | | | | | | | |
| AU-R2 | 4 | 4 | . | . | 4 | . | . | 4 | 4 | . | . | . | . | . |
| AU-R3 | . | 4 | 4 | 4 | 4 | . | . | . | . | . | . | . | . | . |
| **Netherl.** | | | | | | | | | | | | | | |
| NL-R1 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 6 | 13 | . | 13 | . |
| **Rhine** | | | | | | | | | | | | | | |
| R-R1 | . | 26 | . | 14 | 14 | 26 | . | . | . | . | . | . | . | . |

*Sampling frequency*
Usually sampling frequency of radioactivity variables corresponds to sampling frequency of other variables in a monitoring programme. In the Austrian river monitoring programmes, harmful substances including radioactive variables are sampled less frequent than the general variables.

**Microbiological determinands.**
The most commonly employed microbiological variables are measurement of faecal bacteria. These are not necessarily infectious to humans, but are good indicators of discharge of poorly treated urban wastewater. Thus, microbiological variables are highly related to assessment of the quality of water used for drinking, bathing or mussel production.

As soon as faecal bacteria are emitted to natural waters they rapidly become insignificant. These variables are therefore measured relatively closely to known or suspected outlets, ie. in river systems passing through inhabited areas or coastal areas. Furthermore, sampling is carried out in the water compartment, as the bacterial density in sediment rapidly declines. Most monitoring programmes in which analyses of microbiological variables are conducted are thus inland surface water programmes. The French and Irish programmes for marine environment primarily monitor coastal areas with special reference to classification of bathing waters or shellfish production areas.

The most frequently occurring variables are faecal coliforms, total coliforms, Salmonella and faecal Streptococci. Austria carries out plate counts in connection with several monitoring programmes, and a few additional variables are included in one programme.

**Table 4.6.6.** Sampling frequency of microbiological variables.

| Country /code | Faecal coli | Total coli | Faecal Strept. | Salmo-nella | Other vars. |
|---|---|---|---|---|---|
| **Austria** | | | | | |
| AU-L1 | . | . | . | . | 12 |
| AU-L2 | 2 | 2 | 2 | 2 | 2 |
| AU-R1 | 6 | . | . | . | 6 |
| AU-R2 | 4 | 4 | . | . | 4 |
| AU-R3 | 4 | 4 | 4 | 4 | 4 |
| AU-R5 | 9 | 9 | 9 | 9 | 9 |
| AU-R8 | 1 | 1 | . | . | 1 |
| **Belgium** | | | | | |
| BE-R1 | 8 | 8 | 8 | 8 | . |
| BE-R5 | 5 | 5 | 5 | . | . |
| **Spain** | | | | | |
| ES-R1 | . | 12 | . | . | . |
| **Finland** | | | | | |
| FI-R1 | . | 4 | 4 | . | . |
| **France** | | | | | |
| FR-M2 | x | . | . | x | . |
| **Ireland** | | | | | |
| IE-M4 | 7 | 7 | x | x | x |
| IE-M5 | 26 | . | . | . | . |
| **Luxembourg** | | | | | |
| LU-L1 | 8 | 8 | 8 | . | . |
| **Netherl.** | | | | | |
| NL-R1 | 13 | . | 13 | 13 | . |
| **Norway** | | | | | |
| NO-L3 | 12 | . | . | . | . |
| NO-L4 | 12 | . | . | . | . |
| **Portugal** | | | | | |
| PT-R1 | 12 | 12 | 12 | 12 | . |
| **UK** | | | | | |
| UK-R1 | x | x | x | x | . |
| UK-M5 | 20 | 20 | 20 | 20 | . |
| **International** | | | | | |
| EU-R1 | 12 | 12 | 12 | 12 | . |

*Sampling frequency*

In most monitoring programmes sampling frequency of microbiological variables equals sampling frequency of physical/chemical variables. In programmes with special reference to microbiological pollution, however, sampling frequency varies depending on the actual situation, eventually sampling under certain conditions. This is the case in the Irish IE-M4 recreational area programme and the French FR-M2 microbiological programme.

# 5. Conclusion

The current report gives an overview of national surface water quality monitoring activities in the countries in the European Environment Agency (EEA) area. The results from these national and large regional monitoring programmes could make the basis for the evaluation of the state and trends in water quality at the EEA level. On the basis of the current report and additional analyses, a European surface water information system could be elaborated, including criteria for incorporating national monitoring sites into the EEA network, proposals for harmonization and sampling procedures and variables to be measured, and ideas for information processing from national level to the EEA level.

The report presents summary descriptions of the monitoring activities in each country based on the supplied national descriptions. Generally, the countries have several national monitoring programmes focused on assessment of the environmental state of surface waters. Some countries have a long tradition for national coordination of their monitoring programmes, however, in most of the countries the monitoring of surface waters has traditionally been performed by regional or local organisations. During the 1980s and 1990s the growing need for national information on the environmental state of surface waters made it necessary to work out national coordinated monitoring programmes. In most cases these national programmes are based on the information collected by regional organisations.

Nearly all countries in the EEA area have a national monitoring programme with the purpose of assessing the chemical water quality of rivers. The networks consist generally of more than 100 sampling sites located in all major river systems and rivers in each country. In most of the programmes basic variables (eg. water flow, temperature, pH, conductivity), organic pollution indicators (eg. BOD5, dissolved oxygen, ammonium), nutrients (nitrogen and phosphorus), specific ions (eg. chloride, sulphate, potassium, calcium) are measured. At a reduced number of sampling sites heavy metals and organic micropollutants are generally measured. The sampling and measuring frequency are generally monthly or even more frequent. Most of the countries also have

monitoring programmes with the purpose of estimating the riverine loading into coastal areas, or the loading by transboundary rivers. In the Nordic countries programmes have been established with the purpose of monitoring water quality and loading from small catchments. These monitoring programmes generally consist of up to 20 relatively small stream catchments with detailed integrated studies of both river water quality and of the catchment (eg. land use and soil type), the main purpose being to follow reference areas, loading from agricultural land or impact of acid precipitation.

Most European countries have a long tradition for local assessment of the river quality based on studies of macroinvertebrates. In some countries these activities have developed into national surveys/classifications of the biological quality of the main rivers. These national surveys are generally based on the results collected by the local organisations and made possible through national harmonisation and standardisation. In some countries (eg. Austria, Germany, Ireland, Luxembourg, and the United Kingdom), the national classification has been performed since the 1970s and the countries are generally assessing the river quality at two to five years intervals. Some of southern European countries and the Nordic countries have no national programme for the assessment of biological river quality.

Only a minor part of the countries in the EEA area has national monitoring programmes for the assessment of water quality of lakes; some countries have, however, local monitoring of lakes. The Nordic countries with their many natural lakes generally have one or several lake monitoring programmes. Generally, a "survey-type" monitoring programme including a large number of lakes, which are sampled with intervals of several years (5-10 years), is supplemented with more intensive programmes with a sampling frequency of several times a year and typically covering a small number of lakes. The lake monitoring programmes generally include measurement of basic variables (eg. temperature, pH, conductivity, dissolved oxygen), nutrients (nitrogen and phosphorus), specific ions (eg. chloride, sulphate, potassium, calcium). In addition, assessment of biological variables, especially phytoplankton, is also included in many of the lake monitoring programmes.

Norway, Sweden and Finland each have nation-wide surveys in order to assess the extent of acidification. The surveys include national sampling of 200 to more than 1000 water bodies, primarily lakes, and are generally performed with intervals of five to ten years. The Nordic countries and the United Kingdom and Ireland have monitoring programmes involving detailed studies of few catchments with the purpose of understanding the process of acidification and to analyze trends.

Information about marine monitoring programmes has been received from ten out of the seventeen countries. Most countries have one general marine monitoring programme, which may be divided into sub-programmes eg. one programme concentrating on coastal waters and one programme focused at the open marine waters. Most of the marine monitoring programmes include measurement of chemical and physical variables in the water column (basic variables (eg. temperature and salinity), oxygen condition, and nutrients) and many of the programmes include studies of the biota (phytoplankton, zooplankton, zoobenthos etc.). The sampling networks consist generally of a number of intensive sampling sites, typically less than 20 sites, with frequent sampling (> 12/yr) of the water column supplemented with an extensive network including several sampling sites and low frequent sampling (1-4/yr).

Reliable high quality information on the environmental quality of surface waters is essential for water management and the implementation of optimal measures that will improve environmental quality. Greater knowledge of water quality at the regional and European levels is essential if the management of surface waters at the European level is to be improved. The considerable information on the state of surface waters collected and reported by various large regional and national authorities may be a valuable input to a European Surface Water Information System. Consistency and comparability of the information processed by the information system would require some harmonization and standardization of the regional and national monitoring programmes. A successful European Surface Water Information System would have to include the following elements:

- A representative monitoring network,
- A harmonized sampling and analyzing programme,
- National and regional reporting of the environmental state of surface waters.

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**Appendix I:** Tables summarizing the monitoring programmes of each country

**Appendix II:** List of main institutions in each country

**Appendix III:** Table of sampling site information