European Topic Centre on Inland Waters

WATER QUALITY OF LARGE RIVERS

by

Peter Kristensen

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Table of contents

Executive summary

This report aims at assessing the environmental state of major rivers in the European Environment Agency (EEA) area and relating water quality variables to dominant human .activities in river catchments. The report is based on a generally good quality data set of water quality variables while the information about human activities is more sparse and heterogeneous. This lack of information on human activities prevents a full assessment of the relationship between water quality variables and human activities. The assessment could have benefited from more detailed information about land-use characteristics (arable land, use, of fertilizers, etc.) in the river catchments and information about the sources of pollutants (eg. sewage treatment plants) would have been valuable.

The report attempts as far as the information allows at giving a description of the large rivers in the EEA area, their water quality and the relationship between water quality and very broad descriptors of human activities in the river catchments such as population density and percentage of farmland.

Draining the EEA area there are 15 rivers with a catchment area greater than 50.000 km^2. The largest of these, the Danube, discharges into the Black Sea and only a small part of its catchment lies in the EEA area. Of the other 14 the most noticeable feature is the dominance of a westerly or northwesterly flow direction, with only three of the major rivers; ie. the Rhône, the Ebro and the Po dischargmg into the Mediterranean. In total, the report covers around 50 large rivers in the EEA area (the majority of rivers with a catchment area greater than 20.000 km^2 in addition some large rivers in the countries with only relatively small rivers have been included).

Large regional variation in the annual mn-off was found. The large rivers with their source in the Alps as well as the rivers draining the north-western and northern part of the region generally have an annual run-off greater than 500 mm, while the rivers draining the southem part of Iberia have an annual run-off smaller than 200 mm.

In the catchment area of the large rivers in Norway, Sweden, and Finland the population density is generally less than 10 inhabitants per km^2. In the catchment areas of several of the large rivers in the south-western part of the region the population density ranges. between 40 to 100 inhabitants per km^2. In the central part of the EEA area the catchment population density is generally greater than 100 inhabitants per km^2, with the highest densities being observed in the catchment areas of the rivers draining northem France and the Benelux countries, the Italian rivers, the river Rhine, and of the large rivers in the southem part of England. The volume of available water resource per inhabitants ranges from less than 1000 m^3 per inhabitants per year in the most densely populated river catchments to more than 20.000 m^3 per inhabitant per year in the sparsely populated river catchments in the northem part of the EEA area.

Most of the catchment area of the large rivers in Norway, Sweden and Finland is dominated by natural landscape and forest, less than 10% being agricultural land. In the central and southem part of the EEA area the catchment of the large rivers generally contain 40 to 60% agricultural land, the percentage of forest and natural land (eg. mountains, wetlands, arid land) varying between 10% and 50%. A more detailed categorization of the agricultural land (eg. in arable land, rough grazing and permanent crops) has not been possible.

The large rivers have been divided into three regions: the northem region: large rivers draining Iceland, Norway, Sweden, Finland and Scotland; the central region: large rivers draining Denmark, Germany, the Benelux countries, northem France, Ireland, Northem Ireland, England

and Wales; and the southem region: large rivérs draining southem France, the Iberian Peninsula, Italy, and Greece. The annual average water temperature was generally between 1 l-14°C in the large rivers in the central region and between 14-18 °C in the rivers in the southem region (no temperature data from the rivers in the northem region). The pH was markedly lower in the northem rivers, while most of the rivers in the central and southem regions had annual average -pH levels between 7.5 and 8. The conductivity levels were lowest in the northem rivers, medium in the southem rivers and highest in the rivers in the central region.

The level of organic matter (BOD,) was quite similar in the large rivers of the central and southem part of the EEA area (no BOD_5 data from the northem region). The ammonium level is an order of magnitude lower in the northem rivers, medium in the southem rivers and highest in the rivers draining the central part of the EEA area. An increasing ammonium concentration was found with increasing population density in the river catchments.

During the last 15-20 years biological treatment of domestic and industrial waste waters has intensified, and organic matter loading has consequently decreased in many parts of Europe. This reduction in organic loading of the rivers is reflected in a similar reduction in the concentration of BOD, in many of the large rivers. A comparison of organic matter levels (BOD_5) at 101 river stations in large rivers in the EU12 Member States (no BOD, data from Norway, Sweden and Finland) reveals signs of improving conditions. From the period around 1980 to 1990- 1992, the organic matter concentration decreased at almost 72% of the river stations. The improvement was greatest in the rivers in the north-western Member States, while in the southern Member States 15 stations had decreasing concentration and 16 stations increasing BOD, levels. A similar reduction in the ammonium concentration were observed. The ammonium concentration decreased at 65% of 130 stations at large rivers in the EEA area between the beginning of the 1980's and 1990-1992.

The levels of nutrients were an order of magnitude lower in the large rivers of the northem region compared to the other large river in the EEA area. The phosphorus concentrations were generally higher in the more densely populated central region than in the large southem rivers. A positive correlation was found between the population densityand annual average river water phosphorus concentration.

A markedly higher nitrate concentration was observed in the large rivers of the central region compared to these of the southem region. The nitrate concentration is significantly correlated to the percentage of farmland in the river catchments. In rivers with the percentage of agricultural land greater than 40% the nitrate level was about double in the large rivers draining the central part of the EEA area compared to the large rivers in the southem part. These regional differences in the nitrate levels can be explained by differences in agricultural intensification. In both the central and the southem region the percentage of farmland is around 60%, however, in the central region the usage of nitrogen fertilizers is approximately double the usage in the southern region.

The concentration of phosphorus decreased between the beginning of the 1980s and 1990-1992 in the majority of the large rivers. In contrast, the nitrate level in the large rivers has generally been increasing the last 10-15 years. Thus, the nitrate levels increased between the beginning of the 1980s and 1990-1992 in nearly three quarters of 120 river stations.

1. Introduction

The European Environment Agency (EEA) was established under Council Regulation No. 1210/90 and was given a task to:

> *"provide the Community and the Member States with objective, reliable comparable information at the European level enabling them to take the measures to-protect the environment, to assess the results of measures and to ensure that the public is properly. informed about the state of the environment."*

To assist in this task, the EEA established five European Topic Centres (ETC) in December 1994 addressing media-oriented monitoring projects on air quality, air emissions, inland waters, marine waters and coastal zone management (scoping study only) and nature conservation. This report has been prepared by the European Topic Centre on Inland Waters (ETC/IW) as Task 15 of the 1994 subvention technical work programme.

The task description is as follows:

> *Once the river database (relating to the Exchange of Information Decision) has been updated (Task 12), the data will be analyzed to produce a report relating water quality (in terms of the reported variables) in particular in large rivers to dominating human activities (e.g. agriculture, forestry, sewage discharges) in their catchments. The latter information should be available, and will neèd to be collated, from existing databases. Trend analysis will be undertaken on those data collected in a consistent way (e.g. in terms of methodology, limits of detection, frequency) over a long period. In terms of this project it should be possible to produce such a report on the most recently collected data. The draft report will be circulatedfor discussion and review by EEA, EIONET and other collaborators.*
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> *Part of this work also formed part of the successful Tender to DGXI mentioned in Task 12, the two successful organisations, NERI and WRc, will therefore take a full part in this task.*

1.1 Aims and approach

This report aims at assessing the environmental state of major rivers in the European Environment Agency (EEA) area and relating water quality variables to dominant human activities in river catchments. The report is based on a generally good quality data set of water quality variables while the information about human activities is more sparse and heterogeneous. This lack of information on human activities prevents a full assessment of the relationship between water quality variables and human activities.

The report attempts, as far as the information allows, at giving a description of the large rivers in the EEA area, their water quality and the relationship between water quality and very broad descriptors of human activities in the river catchments such as population density and percentage of farmland. The primary focus is on frequently measured water quality variables (physical variables, organic pollution indicators and nutrients) since the wide-geographical coverage makes these variables well-suited to illustrate the general environmental state of large rivers in the EEA area. Many other pollutants and human activities affect the environmental state of large rivers (eg. heavy metals, organic micropollutants, river regulation), however, it has not been possible to find comparable information to describe these problems at the EEA level.

1.2 Data and information sources

River water quality data on the majority of large rivers in the EEA area are generally available, while information about human activities in river catchment areas is sparse and very heterogeneous. A review of European sources (databases, reports etc.) aimed at gathering information about human activities in the river catchment areas revealed only little relevant and useful information. The present study of human activities in the river catchment areas could not be based on available information from existing databases as planned, therefore it has been necessary to use large resources to collate information. A questionnaire asking for information about human activities in the major river catchments was distributed to the ETC/IW partners on 22 June 1995. During July and August information describing human activities in most of the large river catchments was received. In addition, information from various national state of the environment reports as well as Eurostat regional statistics (population, land-use etc.) has been used (Eurostat, 1995). The information provided was very heterogenous and not always comparable.

Water quality data on major rivers in the EEA area

Exchange of information

Council Decision No. 77/795/EEC of 24 December 1977 established a common procedure for the exchange of information on the quality of surface fresh water. According to the Decision the Member States measure 18 specified physical, chemical, microbiological and biological parameters at 126 stations, located mainly in the large rivers of EU12 Member States, and report ,the information to the Commission each year. The database established for the Exchange of Information data includes data for the period 1977-1992. However, Greece and Italy started reporting data in 1982, whilst Portugal and Spain commenced in 1986. In total, data on 18 parameters are stored in the database: water flow, water temperature, pH, conductivity, chloride, nitrate, ammonium, dissolved oxygen, BOD,, COD, total phosphorus, surfactants, cadmium, mercury, faecal coliform, total coliform, faecal streptococci, and salmonella. The measuring frequency has generally been monthly. The Commission of the European Communities has reported the results of the Decision in the form of three reports: the first report covered the period 1982 to 1986 (Commission of the European Communities, 1989), the second covered the period 1987 to 1989 (Commission of the European Communities, 1995), whilst the third report covering the period 1990 to 1992 exists in a draft form and has been put out to Member States for comments. The last report has in 1995 been prepared for the Commission by two partners of the ETC/IW - NERI and WRc. The report addresses the degree to which Member States have complied with the requirements of the Decision in the period 1990-1992 and describes, as far as the data allows, temporal and spatial trends in water quality. NERI and WRc are grateful to Ms. Kroll, DG XI D. 1 for her advice and ideas for preparation of the report.

In the current report the focus has been put on a more general characterization of the large rivers and especially water quality data from the downstream stations have been used. The Exchange of Information water quality data have been supplemented with information about human activities derived from the questionnaire sent to ETC/IW partners and a literature review.

EEA-TF database used for the Dobris Assessment

NERI has been responsible for preparation of the EEA report "European Rivers and Lakes" (Kristensen & Hansen, 1994) being used as a background document for the inland surface water section of the report "Europe's Environment - the Dobris Assessment" (EEA, 1995). During the preparation of this report much information about large European rivers was collected and stored in a database. Only sparse information was reported by the EU12 Member States, however, from Iceland, Norway, Sweden, Finland and Austria some information about the large rivers was provided. For many large rivers water quality time series data for 1980-1992 as well as descriptions of the river catchments exist (eg. catchment area, land-use category, population

density). The relevant information about large rivers in the EEA area has been included into the present report.

Quality of data

The report is based on a generally good quality data set of water quality variables while the information about human activities is more sparse and heterogenous. The quality of data on physical variables (eg. water flow, temperature, pH and conductivity), organic pollution indicators (BOD, and ammonium) and nutrients (nitrogen and phosphorus) are generally high ie. measured frequently, at the majority of stations and by the use of generally comparable analytical methods, while the quality of data conceming surfactants, heavy metals and microbiological indicators generally is markedly lower. In particular, most of the observations for surfactants and heavy metals have been reported as values below the detection limit used, which has varied between river stations and within stations tbrough time. This makes evaluation of trends of these variables problematic as well as regional comparisons between rivers very doubtful. The primary focus in the report is put on the physical variables, organic pollution indicators and nutrients since the generally high quality of these variables and the wide geographical coverage makes well-suited to illustrate the general environmental state and temporal trends in water quality of the major rivers in the EEA area.

The lack of information on human activities prevents. a full assessment of the relationship between water quality variables and human activities. The assessment could have benefited from more detailed information about land-use characteristics (arable land, use of fertilizers etc.) in the river catchments as well as information about the sources of pollutants (eg. sewage treatment plants and industry).

The large rivers have been divided into three regions: the northem region: large rivers draining Iceland, Norway, Sweden, Finland and Scotland; the central region: large rivers draining Denmark, Germany, the Benelux countries, northem France, Ireland, Northem Ireland, England and Wales; and the southem region: large rivers draining southem France, the Iberian Peninsula, Italy, and Greece.

4. Conclusions

This report aims at assessing the environmental state of the major rivers in the EEA area and to relate water quality variables to the dominant human activities in their catchments. The report is based on a generally good quality data set of water quality variables, while the information about human activities is sparse and heterogeneous. This lack of information on human activities prevents a full assessment of the relationship between water quality variables and human activities. The assessment could have benefited from more detailed information about land-use characteristics (arable land, use of fertilisers, etc.) in the river catchments and information about the sources of pollutants (eg. sewage treatment plants, industry) would have been valuable.

The countries or the local authorities generally produce and collate much information about human activities in the river catchments and make inventories of pollutant emissions from point sources into the rivers. However, this information may be hard to obtain (reported in specific reports), and as the methods used for assessing pollution loads differ the information may not be directly comparable. In the coming working period (1996) one of the ETC/IW projects will be to produce guidelines for inventories of pollutant emissions into surface waters. In addition, the Topic Centre for Land Cover as well as Eurostat will, hopefully, in the years to corne be able to collate more detailed and comparable information about land-use and agricultural activities in the large river catchments areas.

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There are 15 rivers with a catchment area greater than 50.000 km^2 clraining the EEA area. The largest of these, the Danube, discharges into the Black Sea and only a small part of its catchment lies in the EEA area. Of the other 14 the most noticeable feature is the dominance of a westerly or northwesterly flow direction, with only three of the major rivers; i.e. the Rhône, the Ebro and the Po discharging into the Mediterranean. In total, the reports covers around 50 large rivers in the EEA area .

Large regional variations in the annual run-off were found. The large rivers with their source in the Alps and the rivers draining the north-western and northem part of the EEA area generally have an annual run-off greater than 500 mm, while the rivers draining the southem part of the Iberian Peninsula have an annual run-off smaller than 200 mm.

In the catchments of the large rivers in Norway, Sweden, and Finland the population density is generally less than 10 inhabitants per km^2. In the catchments of several of the large rivers in the south-western part of the region the population density ranges between 40 to 100 inhabitants per km^2. In the central part of the EEA area the catchment population density is generally greater than 100 inhabitants per km^2, with the highest densities being observed in the catchment areas of the rivers draining northem France and the Benelux countries, Italian rivers, the river Rhine, and the large rivers in the southem part of England. The volume of available water resource per inhabitant ranges from less than 1000 m^3 per inhabitants per year in the most densely populated river catchments to more than 20.000 m^3 per inhabitant per year in the sparsely populated river catchments in northem part of the EEA area.

Most of the catchments of the large rivers in' Norway, Sweden and Finland are dominated by natural landscape and forest, with less than 10% being agricultural land. In the central and southem part of the EEA area the catchments of the large rivers generally contain 40 to 60% agricultural land with the percentage of forest and natural land (eg. mountains, wetlands, arid land) varying between 10% and 50%. A more detailed categorisation ofthe agricultural land (eg. in arable land, rough grassing and permanent crops) has not been possible.

The level of organic matter (BOD,) was quite similar in the large rivers of the central and southem part of the EEA area (there are no BOD, data from the northem region). Ammonium levels are an order of magnitude lower in the northem rivers, medium in the southem rivers and highest in the rivers draining the central part of the EEA area. An increasing ammonium concentration was found with increasing population density in the river catchments.

During the last 15-20 years biological treatment of domestic and industrial waste waters has intensified, and organic matter loading has consequently decreased in many parts of Europe. This reduction in organic loading of the rivers is reflected in a similar reduction in the concentration of BOD_5 in many of the large rivers. A comparison of organic matter levels (BOD,) at 101 river stations in large rivers in the EU12 Member States (there are no BOD, data from Norway, Sweden and Finland) reveals a sign of improving conditions. From the period around 1980 to 1990-1992, the organic matter concentration decreased at almost 72% of the river stations. A similar reduction in the ammonium concentration was also observed.

The levels of nutrients were an order of magnitude lower in the large rivers of the northem region compared to the other large rivers in the EEA area. The phosphorus concentrations were generally higher in the more densely populated central region than in the large southem rivers. A positive cor-relation between the population density and annual average river water phosphorus con-centration was found.

A markedly higher nitrate concentration was observed in the large rivers of the central region compared to the large rivers of the southern region. The nitrate concentration is significantly correlated to the percentage of farmland in the river catchments. In rivers with the percentage of agricultural land greater than 40% nitrate levels were about double in those large rivers draining the central part of the EEA area compared to those draining the southem part. These regional differences in nitrate level can be explained by differences in agricultural intensification. In both the central and the southem region the percentage of farmland is around 60%. However, in the central region the usage of nitrogen fertilisers is approximately double the usage in the southem region.

In the majority of the large rivers the concentration of phosphorus decreased between the beginning of the 1980's and 1990-1992. In contrast, the nitrate level in the large rivers has generally been increasing over the last 10- 15 years with increases occuring at nearly three quarters of 120 river stations.

When assessing river characteristics and water quality at downstream stations in the large rivers in the EEA area, it is important to bear in mind, that a river comprise not only the main course, but also a vast number of tributaries. Each tributary includes sevéral streams, each with its own characteristics and water quality. A report on the large rivers will only describe the general water quality of these rivers, while the proposed EEA monitoring network covering both small streams and large rivers will when fully implemented give a more detailed and precise overview of the overall environmental state of rivers in the EEA area.