UNITED
NATIONS

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Economic and Social
Council

Distr.
GENERAL

EB.AIR/WG.1/2000/6
7 June 2000

ORIGINAL : ENGLISH

ECONOMIC COMMISSION FOR EUROPE

EXECUTIVE BODY FOR THE CONVENTION ON
LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Working Group on Effects
(Nineteenth session, Geneva, 23-25 August 2000)
Item 4 (b) of the provisional agenda

THE TWELVE-YEAR REPORT: ACIDIFICATION OF SURFACE WATERS IN EUROPE AND NORTH AMERICA

Executive summary

I. INTRODUCTION

1. The Twelve-Year Report: Acidification of Surface Waters in Europa and North America, prepared within the framework of the International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes (ICP Waters), presents the programme activities during the three-year period 1996-98. Twenty-three countries actively participated in the programme during this period. This document reviews and summarizes work done on: (i) the ICP Waters database ; (ii) the representativeness of the programme’s sites; (iii) trends in water chemistry; (iv) the effects of acidification on aquatic fauna (invertebrates); and (v) the assessment of heavy metals.

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II. ICP WATERS DATABASE

2. The original ICP Waters database has been revised and upgraded into a new “Working Database”. Included sites and data were selected on the basis of the following three criteria:

(a) Only active sites are included in the new database, i.e. sites currently operational, which reported data for the period 1996-98 to the programme centre;

(b) Only data on mandatory or optional parameters are included. In addition, where available, data on total organic carbon (TOC), reactive and non-labile aluminium and colorimetrically analysed sulphate were also included;

(c) For lakes, only data for the upper depth are included.

The ICP Waters database now includes 142 sites with chemical data and 123 sites with biological data. Quality control of data is performed annually, and most laboratories have participated in intercalibration exercises for the period 1996-1998.

III. REPRESENTATIVENESS OF THE DATABASE

3. Many of the sites included in ICP Waters are especially sensitive to acidification. They need not be representative of all surface waters in a region, but rather represent the acid-sensitive surface waters. Most of the sites appear to be well suited to monitor changes in acidification in response to changes in acid deposition. The sites are generally representative of the lower acid neutralizing capacity (ANC) and the lower critical loads distributions for all the waters surveyed in the region.

4. The ICP Waters sites cover most of the acid-sensitive areas in Europe that receive significant acid deposition. There are no ICP sites, however, in several regions that have been or are potentially affected. Furthermore, there are insufficient data from many regions in eastern Europe to adequately assess both the risk of acidification and the sensitivity of surface waters.

5. For North America the ICP sites cover several, but not all, of the acid-sensitive regions that receive significant acid deposition, and that can be expected to show changes in response to changing levels of deposition in the future.

IV. TRENDS IN WATER CHEMISTRY

6. Results from 98 ICP Waters sites with sufficient data were tested for trends in concentrations of major chemical components. The non-parametric seasonal Kendall test (SKT) was used to analyse trends within the 10-year period 1989-1998. The trends for each individual site, as well as aggregated trends organized by regions, were assessed. The sites were grouped into regions by means of meta-analysis.

7. All of the regions had highly significant downward trends in SO_4^{2-}. The majority of the individual sites showed a significant decrease in SO_4^{2-}. Nitrate, on the other hand, showed no regional patterns of change. Central Europe did show some significant decreasing NO_3^- trends, but the heterogeneity within the region was too large to identify a regional pattern. Decreasing trends in lake water NO_3^- occurred in the border areas of the Czech Republic, Germany and Poland, while southwest Germany and Italy (Southern Alps) exhibited no or increasing NO_3^- trends. The overall picture of changes in sulphate, nitrate, base cations, ANC and H^+ is shown in figure I.

8. Recovery in acidification reflected by an increase in surface water ANC and pH is significant in the Nordic Countries/United Kingdom region. Lack of recovery during the past decade at the individual United Kingdom sites has been attributed to: (i) the absence of significant reductions in deposition of sulphur in western areas; and (ii) the impact of natural climatic variations on water chemistry (seasalt episodes). In central Europe, there was a regional tendency toward increasing ANC, but significant heterogeneity. Two important regions failed to show significant recovery. In eastern North America there was no regional pattern for ANC or pH, while northern Nordic Countries showed an increase in pH but no regional pattern for ANC. Concentrations of base cations declined in most regions. All of the regions showed tendencies towards increasing values for dissolved organic carbon (DOC).

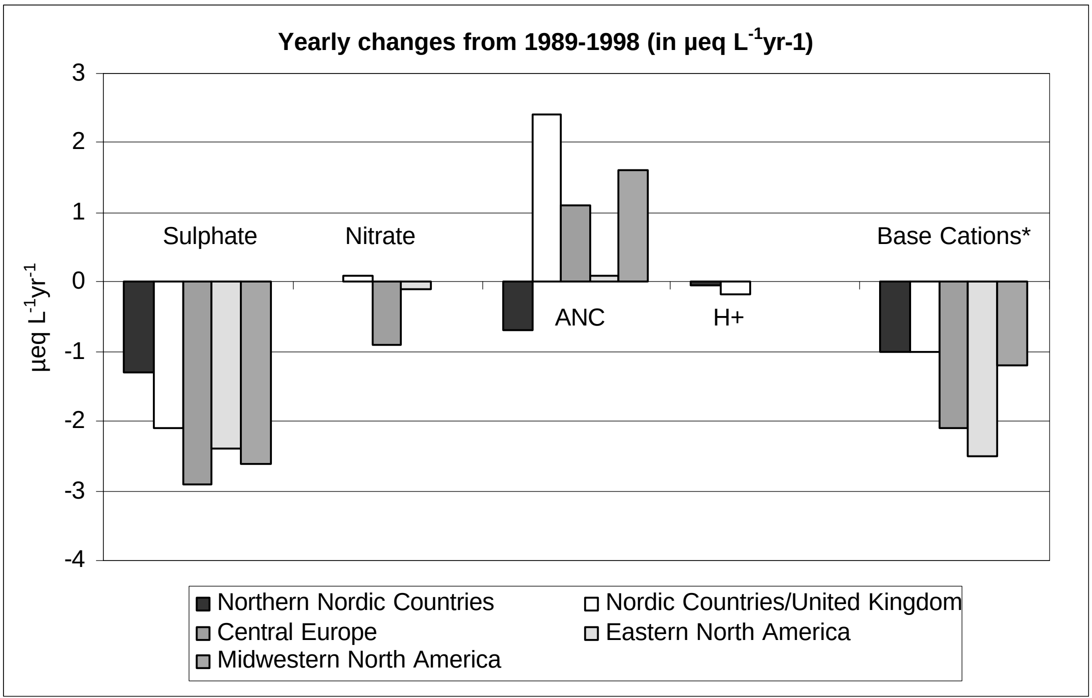

Figure I.
Yearly changes in sulphate, nitrate, ANC, H^+ and base cations for the 10-year period 1989-1998 for five "regions" in Europe and North America

9. The sites were also grouped according to several non-geographical characteristics (chemistry and site characteristics). It was shown that the low ANC sites experienced the highest

rates of recovery. Non-forested sites showed clear and consistent signals of recovery in ANC and pH, and expected (relative to SO_4^{2-} trends) rates of base cation declines. Hence, the observed recovery was, in fact, associated with declining SO_4^{2-}. Nitrate showed a much more complicated picture, and neither the high NO_3^- nor the low NO_3^- groups of sites exhibited significant trends in NO_3^- concentrations.

V. BIOLOGY

10. The effects of acidification on aquatic fauna were described for Ireland, the United Kingdom, Scandinavia and central Europe (including lowland as well as mountain areas). For the United Kingdom and most sites in Germany no statistically significant trends in acidification were recorded, but positive signals of improvements in the invertebrate fauna were observed. A clear positive trend was found for the Norwegian sites and for most of the Swedish sites. An example of the improving conditions for invertebrates is shown in figure II.

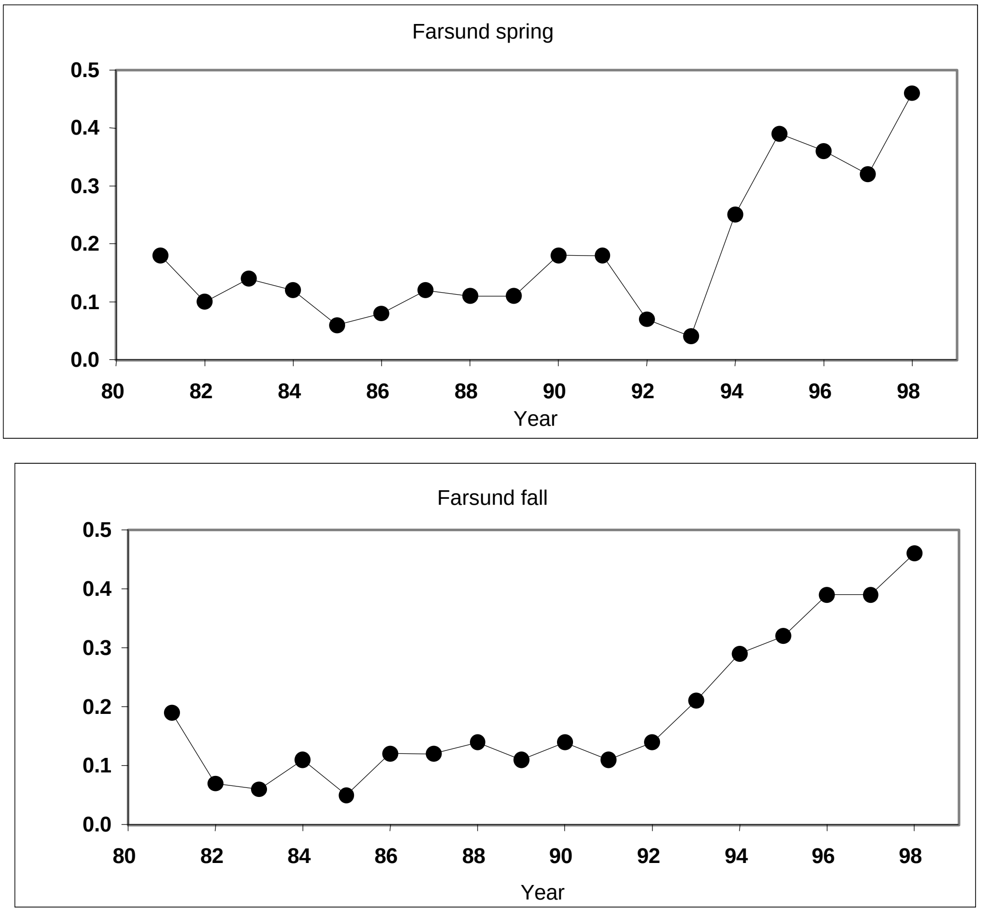

Figure II.
Development of the acidification index during spring (upper panel) and autumn (bottom panel) in Farsund, southern Norway. Low acidification index (0) indicates that the system is acidified and therefore the biota is damaged. Increasing acidification index (up to 1) indicates the lake is recovering.

11. At the most acidic sites in central Europe, improvements in water quality have not yet reached a level where stable effects on biology could be detected. Biological recovery of such sites requires considerable and stable improvements in water quality with respect to acidification.

12. Critical limits of ANC are suggested for the different regions. For Ireland, the United Kingdom and Norway, ANCs of 20 µeq/L are proposed. For Sweden, Germany and the Vosges mountains of France, the limit is set to 50 µeq/L. In the high Alps and Pyrenees, the present information indicates a limit of about 30 µeq/L.

VI. HEAVY METALS

13. The ICP Waters database contains a number of sites with heavy metals data. These sites, however, are located in relatively few countries and, furthermore, these countries report heavy metals data from fewer sites than data on major chemistry.

14. Few sites have long-time series of data on heavy metals. The analytical methods have changed and the detection limit has generally decreased through any long periods of monitoring. Figure III gives a good example of consistent long-time series from the Czech Republic, showing a decrease in Pb and Cd over the past 10 years.

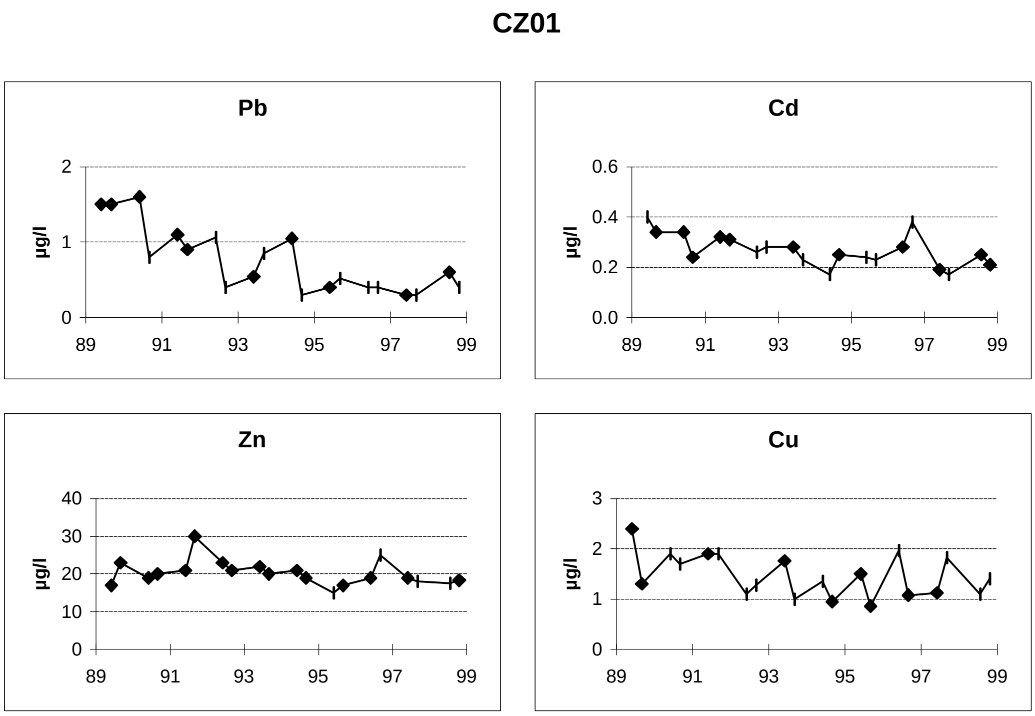

Figure III.
Trends in Pb, Cd, Zn and Cu for Lake Èerné (CZ01) in the Czech Republic. Units in µg/L

15. An analysis of the currently available limited data on concentrations of heavy metal indicates that the ecological effects of long-range transported heavy metals are probably minor. However, heavy metals data for more sites, ensuring a more complete geographical coverage of the region, would be needed for a reliable assessment of the general level of heavy metals in surface waters and of their effects throughout Europe and North America. While some National Focal Centres reported on the availability of data on heavy metals from additional sites on rivers, these sites are not likely to be suitable for monitoring the effects of air-transported heavy metals on surface waters.

16. The heavy metals data that are included in the ICP Waters database have been analysed by national laboratories using different analytical methods of different analytical precision. Regular intercalibration of heavy metals analysis is essential for further improving the results, allowing their meaningful comparison and interpretation on a regional scale. Hence, intercalibration of heavy metals analysis methods should be part of the yearly intercalibration exercise. It should be noted that all laboratories reporting heavy metals data to ICP Waters participated in national and international intercalibration exercises.

VII. FUTURE PERSPECTIVE OF THE PROGRAMME

17. ICP Waters is well equipped to monitor and assess the environmental impact of reduced S and N emissions resulting from the implementation of the new Gothenburg Protocol. The positive trends already documented by the programme’s water chemistry and biology data are likely to continue to reflect the reduced emissions of S and N.

18. The results of ICP Waters presented in its twelve-year report and summarized here, clearly show that surface waters respond to changes in atmospheric deposition. Indeed, waters are much more responsive than either soils or terrestrial vegetation to changes in long-range transported acid pollutants. Lakes and rivers also have the advantage that they reflect an effects response integrated over the entire catchment area. The ICP Waters network covers a broad geographical area and the programme’s database includes long-term series of data (> 15 years) for many sites. The network is thus well suited to document changes that result from the implementation of the protocols to the Convention.

19. The most developed ICP Waters activities are those aimed at monitoring and assessing major-ion chemistry and chemical parameters associated with acidification. Expanding sampling programmes at individual sites to ensure the monitoring of more of the existing biological parameters, as well as adding new biological parameters, could substantially strengthen the network. As already shown, the invertebrate fauna responds to changes in water chemistry, and is a suitable group of organisms for monitoring purposes. With further continuing decreases in acidification of surface waters, the rate of recovery of damaged groups of organisms should increase.