TWENTY-FIVE YEARS OF EFFECTS RESEARCH FOR THE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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ABSTRACT

Concerns on the harmful effects of air pollutants in 1970s prompted international collaboration to combat air pollutants at their sources. The Convention on Long-range Transboundary Air Pollution was established in 1979, with subsequent setup of its working bodies. They included the Working Group on Effects, which laid the basis for the cooperative monitoring and research of air pollution effects. This group comprises several international cooperative programmes and task forces. They cover a variety of receptors from ecosystems (forests, surface waters, vegetation) to materials and health effects on populations, including mapping activities and integrated monitoring. The research addresses many interlinking environmental problems and causative pollutants: acidification, terrestrial eutrophication, health effects, corrosion, ozone, particulate matter, contamination by heavy metals and persistent organic pollutants. The observational and modelling results cover the geographical area United Nations Economic Commission for Europe (UNECE) and the recorded trends span more than 15 years. The effect-oriented work has initiated and supported the development of several air pollutant emission reduction protocols under the Convention, some based on effects-based model calculations. The cooperation has created a nexus of observational networks and interdisciplinary policy-linked research unique in the world.

1 INTRODUCTION

The 1979 Convention of Long-range Transboundary Air Pollution [1] established a broad framework for the UNECE region (of Europe, Central Asia and North America) to work cooperatively addressing the transport of pollutants through the atmosphere and over borders, oceans and continents. The Convention entered into force in 1983 and now has 49 Parties including the European Community. It has been extended by eight specific protocols, of which seven are in force. The Convention and its protocols identify the need for Parties to carry out research and development, to exchange scientific and technical information and to take part in monitoring programmes. To promote such activities the Convention has established scientific and technical programmes to improve understanding of the transport and effects of pollutants and to provide the scientific underpinning for decision making (Figure 1).

Even before the Convention's entry into force the first groups of nominated governmental experts were set up to collect and assess knowledge on possible causes of environmental problems observed in Europe. This work was soon being developed further under the Convention's Working Group on Effects [2]. Certain countries took the lead for International Cooperative Programmes (ICPs) and chaired programme Task Forces that brought together the national experts. Each ICP was responsible for studying effects on particular parts of the environment. Some countries, often the lead countries, set up international centres to coordinate the work, analyze the results and prepare reports. The work was recently evaluated in a substantive report on the ICP results [3].

This paper summarizes the development, structuring and main achievements of the ICPs. It describes the steps and activities linked to the implementation, review and revision of the Convention protocols.

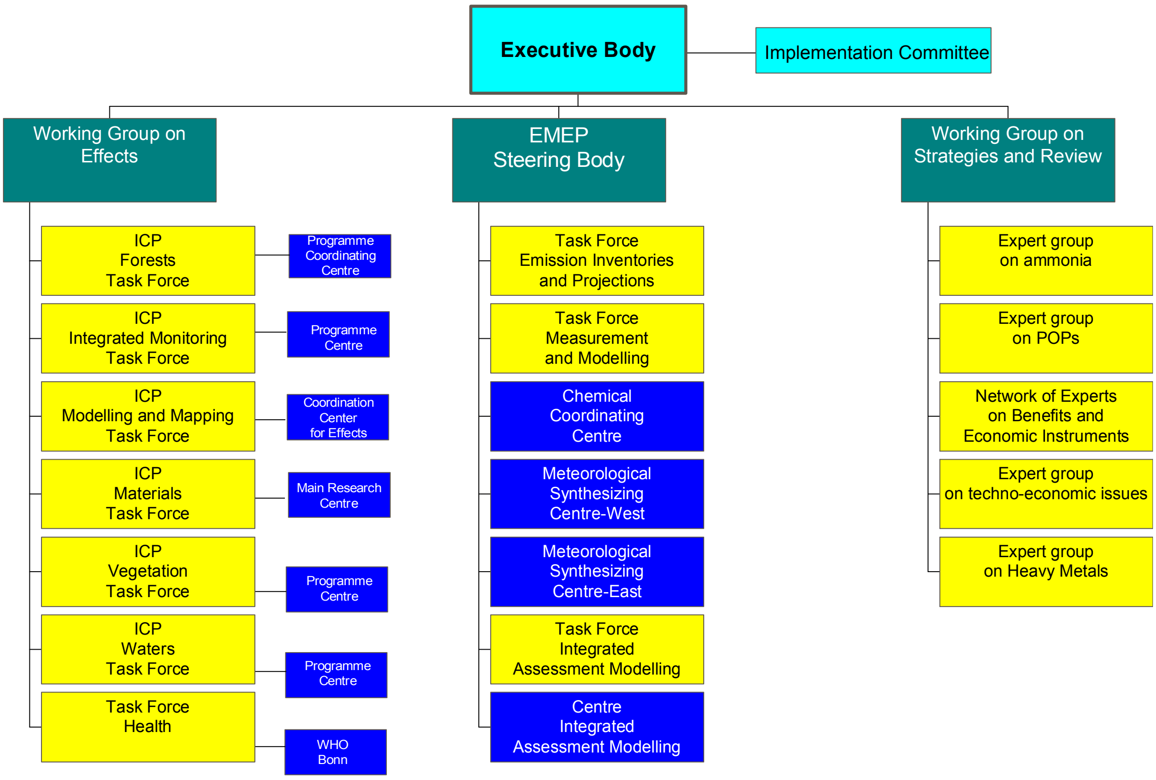

Figure 1. The structure of intergovernmental bodies, expert groups and scientific centres under the Convention on Long-range Transboundary Air Pollution.

2 INTERNATIONAL COOPERATIVE PROGRAMMES

ICP on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)

In the early 1980s a severe deterioration of forest condition was observed in large areas of Europe. As a response to growing concern about the role of air pollution in this decline, ICP Forests was established in 1985. Germany has been the lead country of the programme since the beginning and the Federal Research Centre for Forestry and Forest Products in Germany has hosted the Programme Coordinating Centre. Since 1986 the monitoring activities have been carried out in close cooperation with the European Commission. Currently 40 countries contribute to the programme. [4]

A systematic large-scale, transnational network of around 6000 monitoring plots has been providing data from annual assessments of tree crown condition. Weather conditions and air pollution were explanatory variables of the high spatial and temporal variation of crown condition along with biotic factors and tree age. More than 850 intensive monitoring plots were installed to contribute to a better understanding of the relationships between the condition of forest ecosystems and stress factors, in particular air pollution. The site-specific calculations indicate, that the critical loads of acidity and nitrogen are still exceeded on many sites, as well as the critical levels of ozone.

ICP on Effects of Air Pollution on Materials, Including Historic and Cultural Monuments (ICP Materials)

The detrimental effects of air pollutants on materials, including cultural heritage, have been known for a long time. ICP Materials started its official activities in 1986. Sweden, as the lead country, provided the Main Research Centre. The aim was to evaluate the effects of air pollutants and climate parameters on the corrosion of important materials, including cultural heritage. The programme has test sites in several countries for exposing material samples and measuring of environmental parameters. Currently 19 Parties participate in the work. [5]

The observed reductions of corrosion rates for many materials in the order of 30-70% has been mainly due to the decreasing trend of sulphur emissions. Sulphur was earlier the dominating pollutant for damage, but currently nitrogen oxides, ozone and particulate matter are becoming more important. The effect of exposure of several pollutants simultaneously was investigated with a multi-pollutant exposure programme in 1997–2001. Dose-response functions between pollutant exposure and corrosion have been developed. They can be used for mapping areas where acceptable levels of corrosion are exceeded and for calculation of costs caused by pollutants to technical materials and to cultural heritage.

ICP on Assessment and Monitoring of Acidification of Rivers and Lakes (ICP Waters)

ICP Waters was established in 1985. In the first meeting in 1986 the aims were designed to assess, on a regional basis, the degree and geographical extent of acidification of surface waters and to describe and evaluate long-term trends in aquatic chemistry and biota attributable to atmospheric pollution. The initial phase of the programme under the leadership of Canada ended in 1986 by finalizing the programme manual. For the subsequent implementation phase Norway became the programme lead country and it also hosts the Programme Centre. Currently 19 Parties host a national focal centre for the programme. [6]

The monitoring network is geographically extensive and includes data series of more than 15 years for many sites. The programme conducts yearly intercalibration on chemistry and biology. Since 1990 the majority of the sites show significant downward trends in sulphate. Recovery from acidification is manifested by increasing pH and acid neutralizing capacity. More than half of the sites show a high degree of nitrogen saturation and a clear relation between measured nitrogen concentrations and nitrogen deposition. Long-term trends show improvements in the invertebrate fauna, an indicator for air pollution effects, for many sites. Preliminary results indicate that long-range transported heavy metals probably have only minor ecological effects.

ICP on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation)

This programme was established in 1987 as a response to the growing concern about crop damage caused by ozone pollution. The United Kingdom has been the lead country for this programme from the start. Since 1998, the Coordination Centre has been at the Centre for Ecology and Hydrology, Bangor, United Kingdom. In its early years, the programme focused on the impacts of ozone on crops. Later the remit broadened to include the effects of ozone on (semi-) natural vegetation and the assessment of atmospheric deposition of heavy metals to crop plants and mosses. The programme currently includes contributors from 31 Parties to the Convention. [7]

Since 1994, the programme has shown that incidences of ozone injury have occurred at least once on white clover at each of the 35 biomonitoring sites, and several times per year at many of the sites. Foliar damage by ozone, resulting in loss in commercial value, has also been detected on over 20 agricultural and horticultural crops growing in commercial fields in Europe. At many of the biomonitoring sites biomass reductions of a sensitive biotype of white clover have been detected. Critical levels of ozone based on accumulated concentration exposure were derived for crops, forest trees and (semi-) natural vegetation. Recently additional flux-based critical levels (based on accumulated flux of ozone into leaves) were derived for wheat and potato. Results from the European survey heavy metals in mosses indicate that long-range transboundary air pollution appears to account for elevated concentrations of heavy metals in mosses in areas without emission sources or historical mining activities.

ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring)

The pilot programme on integrated monitoring was established as ICP under the Convention with its first Task Force meeting in 1993. Sweden has been the lead country of the programme, and the Programme Centre is at the Finnish Environment Institute. The main aim is to determine the state of ecosystems and catchments and to predict the changes in the long term, with respect to regional variation and the impacts of air pollutants including effects on biota. The programme's database includes information from approximately 50 sites in 21 countries. [8]

Statistically significant decreasing trends of sulphate, nitrate, ammonia and hydrogen ion deposition have been observed at half of the sites. The subsequent decreases in strong acid anions in runoff and soil water have been partly offset by decreases in base cations, resulting in delayed recovery. Results from the sites and other datasets have confirmed that the carbon-nitrogen ratio in soil organic matter, combined with nitrogen deposition is a useful empirical indicator for predicting the risk for nitrogen leaching. Deposited heavy metals show high retention in soils and accumulation especially in the organic layer. Indications on negative effects on biological activity in the soil have been found.

ICP on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping)

A Task Force on Mapping was established in 1988 under the leadership of the Federal Republic of Germany, as part of the programme of action for the development of the critical loads approach and was made responsible for detailed planning and co-ordination of these activities. Its first meeting was held in 1989 and its task was to use and integrate available data on critical levels and loads at the regional, national and local levels, drawing on relevant work of other bodies under the Convention. A Coordination Center for Effects (CCE) was established in 1990 at the National Institute for Public Health and the Environment in the Netherlands. In 1999 the Task Force Programme was transformed into the ICP Modelling and Mapping. Currently 25 countries participate in the programme's work. [9]

The ICP bases its work on the derivation and mapping of critical loads and levels and their exceedance by air pollution in order to assess areas, stocks and population at risk. Critical loads and levels are defined as thresholds for pollutant loads below which no harmful effects are expected to occur in the long-term according to present knowledge. The first European map of critical loads for acidity was compiled in 1991. Critical loads for eutrophication and heavy metals followed later. European databases of critical loads and levels have been used to support the effects-based protocols of the Convention (see Figure 2). The work was recently extended to include dynamic acidification modelling methods to assess time delays of damage or recovery and also include revised methodologies to compute critical loads for heavy metals.

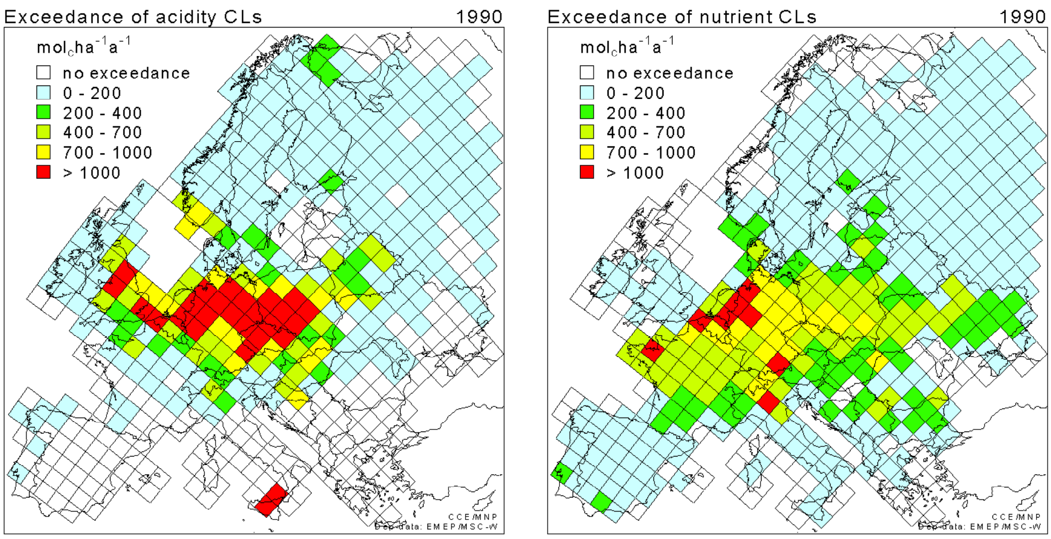

Figure 2. Exceedance of critical loads of a) acidity due to sulphur and nitrogen deposition and b) nutrient nitrogen by nitrogen deposition in 1990 (the base year of the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone) in moles of charge (equivalent acidifying potential of sulphur and nitrogen) per hectare per year in a 150 km x 150 km grid.

Joint Task Force on the Health Aspects of Air Pollution (Task Force on Health)

The Executive Body for the Convention set up the Joint Task Force with the World Health Organization's European Centre for Environment and Health (WHO/ECEH) to address the growing concerns about the impacts of long-range transboundary air pollution on human health. The first meeting was held in 1998 and the work is coordinated by ECEH. The objective of the Task Force on Health is to prepare state-of-the-art reports on the direct and indirect effects of air pollutants on human health. Its main products are assessment reports. Experts from 11-14 Parties have attended the Task Force's meetings. [10]

Most studies point to particulate matter as the strongest air pollution component associated with population health. Ozone peaks are associated with increased mortality and hospital admissions for respiratory diseases. There is also new evidence on the long-term health effects of tropospheric ozone. Due to the rapid progress in research on health effects of the most common air pollutants (particulate matter, ozone, nitrogen dioxide) the new evidence has been reviewed by the Task Force. It has also conducted specific work on the health risks of heavy metals and persistent organic pollutants from long-range transport of air pollutants.

3 CONCLUDING REMARKS

The research results of ICPs have documented widespread effects in Europe and North America caused by air pollution, including acidification, eutrophication, injury to plants and soil biota, accelerated corrosion and health effects. Signs of recovery have been detected after decreases in emissions of air pollutants, in particular sulphur. These were particularly evident in improved surface water quality, which included first signs of biological recovery from acidification, and for the reduction of corrosion rates for many materials. Improved data, models and dose-response relationships today provide a strong scientific basis for predicting environmental effects, risks and trends. They increase the level of confidence of earlier predictions that have supported air pollution abatement policies. Sophisticated models and methods have become available to assess several pollutants and effects simultaneously.

An effects-based approach has proven to be an effective way of meeting environmental goals with overall minimized emission reduction costs; this is reflected in recent protocols under the Convention and related legislation. The effect-oriented work on air pollution effects continues to be the driving force for the work of the Convention. Parties participating in the scientific monitoring, research and modelling programmes contribute the essential data that underpin the work of the Convention. ICPs and Task Forces – with support from their lead countries – provide the vital coordination, assistance and direction to the scientific effort.

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REFERENCES
[1] Convention on Long-range Transboundary Air Pollution, www.unece.org/env/lrtap
[2] Working Group on Effects, www.unece.org/env/wge
[3] Review and assessment of air pollution effects and their recorded trends, Substantive report 2004. Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe, Geneva. In press.
[4] ICP Forests, Programme Coordinating Centre, www.icp-forests.org
[5] ICP Materials, Programme Centre, www.corr-institute.se/ICP-Materials
[6] ICP Waters, Programme Centre, www.niva.no/ICP-waters
[7] ICP Vegetation, Programme Centre, icpvegetation.ceh.ac.uk
[8] ICP Integrated Monitoring, Programme Centre, www.environment.fi/default.asp?contentid=17110&lan=en
[9] ICP Modelling and Mapping, www.icpmapping.org, Coordination Center for Effects www.rivm.nl/cce

[10] Joint Task Force on Health Aspects, http://www.euro.who.int/air/20020628_1, WHO Regional Office for Europe, Air quality and health, www.euro.who.int/air