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Executive Body for the Convention on Long-range Transboundary Air Pollution

Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

Working Group on Effects

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Progress in activities in 2021 and further development of effects-oriented activities: air pollution effects on materials, the environment and crops: integrated monitoring of air pollution effects

Integrated monitoring on air pollution effects on ecosystems

Report by the Programme Centre of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems

Summary

The present report is submitted to the Working Group on Effects as requested by the Executive Body for the Convention on Long-range Transboundary Air Pollution in accordance with the 2021–2022 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2, items 1.1.1.7 and 1.1.1.15–17) and the Revised mandate for the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (Executive Body decision 2019/18).

The report of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems presents the results of the activities undertaken since its 2020 report (ECE/EB.AIR/GE.1/2020/15− ECE/EB.AIR/WG.1/2020/8) and, in particular, the work on assessing long-term developments of exceedance of site-specific critical loads and impacts on measured effects indicators.

I. Introduction

1. The present report of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) is submitted to the Working Group on Effects in accordance with the 2021–2022 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2, items 1.1.1.7 and 1.1.1.15–17) and the Revised mandate for the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (Executive Body decision 2019/18).[1] The report presents the results of the activities carried out between May 2020 and June 2021, and particularly the work on assessing long-term developments on exceedance of critical loads and related impacts on measured effects indicators, as well as an evaluation on recovery of epiphytic lichen communities as a response to rapid air pollution decline.

2. The Programme, which involves some 100 scientists and 48 active sites in 15 countries, has a Task Force led by Sweden and a Centre hosted by the Finnish Environment Institute in Helsinki.[2]

3. During the reporting period, ICP Integrated Monitoring held two meetings: the twenty-eighth Task Force meeting and scientific workshop (online, 13 and 14 May 2020); and the twenty-ninth Task Force meeting and workshop (online, 13 and 14 April 2021).

4. Key topics discussed at the 2021 meeting included the status of the ICP Integrated Monitoring database, the reports to be prepared under the Convention's workplan, cooperation with other bodies and activities and the future workplan of ICP Integrated Monitoring. The scientific workshop focused on current work on the key scientific topics of the Programme (see section IV below). The minutes of the meetings are available from the Finnish Environment Institute website.[3]

II. Outcomes and deliverables during the reporting period

5. In 2020–2021, ICP Integrated Monitoring produced or contributed to the following reports:

(a) The 2020 joint progress report on policy-relevant scientific findings (ECE/EB.AIR/GE.1/2020/3–ECE/EB.AIR/WG.1/2020/3);

(b) Integrated monitoring of air pollution effects on ecosystems (ECE/EB.AIR/GE.1/2020/15–ECE/EB.AIR /WG.1/2020/8);

(c) The 2020 ICP Integrated Monitoring annual report;[4]

(d) A report on mercury and heavy metal trends in concentrations and fluxes in ecosystem compartments of ICP Integrated Monitoring sites in Europe;[5]

(e) A report on long-term changes in the inorganic nitrogen output in ICP Integrated Monitoring catchments in Europe;[6]

[1] Available at www.unece.org/env/lrtap/executivebody/eb_decision.html.

[2] See www.syke.fi/nature/icpim.

[3] See https://www.syke.fi/en-US.

[4] Sirpa Kleemola and Martin Forsius, eds., *Twenty-ninth Annual Report 2020: Convention on Long-range Transboundary Air Pollution. International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems*, Reports of the Finnish Environment Institute, No. 31/2020 (Helsinki, Finnish Environment Institute, 2020). Available at https://helda.helsinki.fi/handle/10138/317512.

[5] Karin Eklöf and others, "Temporal trends and input-output budgets of heavy metals in ICP IM catchments", in Kleemola and Forsius, eds., *Twenty-ninth Annual Report 2020*.

[6] Jussi Vuorenmaa and others, "Long-term changes in the inorganic nitrogen output in European ICP Integrated Monitoring catchments", in Kleemola and Forsius, eds., *Twenty-ninth Annual Report 2020*.

(f) A scientific paper assessing long-term developments on exceedance of critical loads and related impacts on measured effects indicators at ICP Integrated Monitoring sites;[7]

(g) A scientific paper on recovery of epiphytic lichen communities over 20 years of rapid air pollution decline.[8]

III. Expected outcomes and deliverables over the next period and in the longer term

6. In the second half of 2021 and in 2022, ICP Integrated Monitoring will contribute to or produce the following deliverables, as indicated in the Convention workplan:

(a) The 2021 joint progress report on contribution to the review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (ECE/EB.AIR/GE.1/2021/3–ECE/EB.AIR/WG.1/2021/3);

(b) A scientific paper on the impacts of internal catchment-related nitrogen parameters on total inorganic nitrogen leaching;

(c) A scientific paper on the effects of nitrogen enrichment on forest vegetation;

(d) A scientific paper on heavy metal trends in concentrations and fluxes across ICP Integrated Monitoring sites in Europe;

(e) The thirtieth annual ICP Integrated Monitoring report (covering activities in 2020/21), forthcoming in August 2021.

(f) Contribution of ICP Integrated Monitoring to the review process of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol).

IV. Cooperation with other groups, task forces and subsidiary bodies, including synergies and possible joint approaches or activities

7. ICP Integrated Monitoring has established useful cooperation with the following bodies under the Working Group on Effects: the International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping) – on critical load calculations; the Centre for Dynamic Modelling – on changes in biodiversity; the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters); and the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) – on long-term trends, calculations and effects indicators. ICP Integrated Monitoring also uses emission scenario data from the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe.

V. Strengthening the involvement of countries of Eastern and South-Eastern Europe, the Caucasus and Central Asia in work under the Convention

8. A participant from the Russian Federation participated in the ICP Integrated Monitoring Task Force meetings in 2020 and 2021.

[7] Martin Forsius and others, “Assessing critical load exceedances and ecosystem impacts of anthropogenic nitrogen and sulphur deposition at unmanaged forested catchments in Europe”, *Science of the Total Environment*, vol. 753 (January 2021).

[8] James Weldon and Ulf Grandin “Weak recovery of epiphytic lichen communities in Sweden over 20 years of rapid air pollution decline”, *The Lichenologist*, vol. 53, No. 2 (March 2021), pp. 203–213.

VI. Scientific and technical cooperation activities with relevant international bodies

9. ICP Integrated Monitoring cooperates closely with the Long-term Ecosystem Research in Europe network (eLTER)[9] and many sites are common to both bodies. With the approval of two projects with funding from the European Union Horizon 2020 programme totalling €14 million for eLTER, the development of a permanent infrastructure for long-term ecosystem, critical zone and socioecological research in Europe will advance greatly. This funding will enable significant development of the eLTER Research Infrastructure, in areas such as the Research Infrastructure's organization, business model and legal basis. It will also give a major boost to scientific work done at eLTER/ICP Integrated Monitoring sites and platforms. Altogether, 34 partners from 24 countries are involved in these projects.

VII. Highlights of the scientific findings: policy-relevant issues

10. The following findings of ICP Integrated Monitoring are of particular scientific relevance:

(a) The critical load (CL) methodology has been a key science-based tool for assessing the environmental consequences of air pollution. Critical loads are deposition thresholds used to describe the sensitivity of ecosystems to atmospheric deposition. Critical loads for eutrophication and acidification were computed using a long-term data set of intensively studied forested ecosystem ICP Integrated Monitoring sites (n = 17) in Northern and Central Europe.[10] The sites belong to the ICP Integrated Monitoring and eLTER networks. The link between the site-specific calculations and time series of CL exceedances and measured site data was evaluated using long-term measurements (1990–2017) for bulk deposition, throughfall and run-off water chemistry. Novel techniques for presenting exceedances of CLs and their temporal development were also developed. Concentrations and fluxes of sulfate, total inorganic nitrogen (TIN) and acidity in deposition substantially decreased at the sites. Decreases in sulfur deposition resulted in statistically significant decreased concentrations and fluxes of sulfate in run-off, and decreasing trends of TIN in run-off were more common than increasing trends. The temporal developments of the exceedance of the CLs indicated the more effective reductions of sulfur deposition compared to nitrogen at the sites. There was a relation between calculated exceedance of the CLs and measured run-off water concentrations and fluxes, and most sites with higher CL exceedances showed larger decreases in both TIN and H^+ concentrations and fluxes. Sites with higher cumulative exceedance of eutrophication CLs (averaged over 3 and 30 years) generally showed higher TIN concentrations in run-off. The results provided evidence on the link between CL exceedances and empirical impacts, increasing confidence in the methodology used for the European-scale CL calculations. The results also confirm that emission abatement actions are having their intended effects on CL exceedances and ecosystem impacts;

(b) Many lichen species are sensitive to air pollution and react rapidly, especially to sulfur and nitrogen. This sensitivity is augmented by a slow growth rate, growth on substrates often exposed to air pollution and an ability to absorb more sulfur dioxide at a given concentration than most vascular plants. Consequently, many species of lichens were adversely affected by the widespread high levels of sulfur deposition originating in the burning of fossil fuels in industrialized areas, which also spread further afield via long range atmospheric transport. However, over the past decades, there has been a rapid decline in sulfur deposition, but less pronounced deposition trends for nitrogen. The response of epiphytic lichens to this decline was analysed, using data from long-term ICP Integrated Monitoring sites in Sweden. The analysis comprised 20 years' worth of data to investigate temporal trends in lichen communities' sensitivity to sulfur, nitrogen preference, species richness and alpha and beta diversity.[11] Only limited and partial evidence of recovery in the

[9] See www.lter-europe.net.
[10] Martin Forsius and others, "Assessing critical load exceedances".
[11] Weldon and Grandin, "Weak recovery of epiphytic lichen communities in Sweden".

area that previously had high levels of deposition was detected, as well as a decline in mean sulfur sensitivity at a northern site with low deposition levels throughout the monitoring period. The slow recolonization of sensitive species, even where environmental conditions are now suitable, is probably a result of impoverished regional species pools and the inherent limited dispersal capacity of many lichen species. Due consideration of these factors in the use of epiphytic lichens as environmental indicators in a period of improving air quality is therefore suggested.

11. It can thus be concluded that long-term monitoring and research sites are reference systems for detecting long-term ecosystem impacts and for developing and validating critical load calculations and ecological models. The results also indicated that complex ecosystem processes regulate the impacts, accumulation and release of nitrogen and sulfur compounds and their impacts on indicator species, and that a continuous data collection and assessment effort is thus needed.

VIII. Publications

12. A list of ICP Integrated Monitoring publications and references for the present report has been posted on the Finnish Environment Institute/ICP Integrated Monitoring website.[12]

[12] See https://www.syke.fi/en-US/Research__Development/Nature/Monitoring/Integrated_Monitoring/Publications_from_ICP_IM.