United Nations ECE/EB.AIR/GE.1/2015/13–ECE/EB.AIR/WG.1/2015/6

Economic and Social Council

Distr.: General
11 September 2015

English only

Economic Commission for Europe

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

First joint session*
Geneva, 14–18 September 2015
Item 15 of the provisional agenda
Progress in activities in 2015 and further development of effects-oriented activities

Effects of air pollution on rivers and lakes**

Report by the Programme Centre of the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes

Summary

The present report is submitted for the consideration by the first joint session of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe and the Working Group on Effects in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2014–2015 workplan for the implementation of the Convention (ECE/EB.AIR/122/Add.2, items 1.1.10, 1.1.11 and 1.1.15) and the Long-term Strategy for the Convention (ECE/EB.AIR/106/Add.1, decision 2010/18, annex).

* The Executive Body to the Convention agreed that, as of 2015, the Working Group on Effects and the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe should meet jointly, to achieve enhanced integration and cooperation between the Convention's two scientific subsidiary bodies (ECE/EB.AIR/122, para. 47 (b)).

** The present document is being issued without formal editing.

GE.15-15485(E)

The report presents a summary of the discussion and other results from thirtieth meeting of the Task Force under the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (Grimstad, Norway, 14–16 October, 2014) and further progress in 2015, most specifically on water chemistry trends and biological recovery.

I. Introduction

1. The present report of the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) is being submitted for the consideration the first joint session of the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the Working Group on Effects in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2014–2015 workplan for the implementation of the Convention (ECE/EB.AIR/122/Add.2, items 1.1.10, 1.1.11 and 1.1.15) and the Long-term Strategy for the Convention (ECE/EB.AIR/106/Add.1, decision 2010/18, annex)). The report presents a summary of the discussion and other results from the thirtieth meeting of the Task Force of ICP Waters that was held in Grimstad, Norway, from 14 to 16 October 2014, and further progress in 2015.

2. The lead country of the Task Force of ICP Waters is Norway. The Task Force is hosted by the Norwegian Environment Agency and the Programme Centre is located at the Norwegian Institute for Water Research. National Focal Centres of ICP Waters contribute with data and present national results related to assessment and monitoring of air pollution effects on surface waters. ICP Waters collaborates with all the International Cooperative Programmes under the Working Group on Effects as well as the Joint[1] Task Force on the Health Aspects of Air Pollution.

3. The thirtieth meeting of the Task Force of ICP Waters was attended by 30 experts from 13 Parties to the Convention. At present, 29 countries participate in one or more of the activities of ICP Waters. The Task Force considered progress reports from the Programme Centre and the National Focal Centres on the results on trends in water chemistry, biological responses, dynamic modelling, and biodiversity. The presentations from the meeting are included in a recent ICP Waters report.[2,3] A summary of the presentations and discussions at the meeting is presented below (section II).

II. Ongoing activities — report on the 2014 Task Force meeting

4. *Chemical recovery:* Key results from the 2014 report, *Chemical and biological recovery in acid-sensitive waters: trends and prognosis*[4] (item 1.1.15.a) were presented. A steady state model, EMEP deposition data, 30-year discharge and a deposition scenario for 2020 were used to produce a steady-state prediction of water chemistry in circa 60 European ICP Waters sites. The modelled estimates of water chemistry for 2000–2012 described observed trends and mean water chemistry in a satisfying manner, but observed water chemistry showed considerable more variation than modelled water chemistry. This is related to variations in annual climate and deposition. The improvements in water

[1] The Task Force is a joint body of the World Health Organization European Centre for Environment and Health and the Executive Body for the Convention.

[2] Heleen de Wit and Bente M. Wathne, eds., *Proceedings of the 30th Task Force meeting of the ICP Waters Programme in Grimstad, Norway 14 –16 October, 2014*, ICP Waters report 122/2015 (Oslo: Norwegian Institute for Water Research, 2015). Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

[3] The minutes of the Task Force meeting, which include the agenda, the list of participants and the workplan, is available on the ICP Waters website from http://www.icp-waters.no/Publications/TaskForceminutes/tabid/80/Default.aspx.

[4] Garmo, Ø., H. de Wit, A. Fjellheim. Chemical and biological recovery in acid-sensitive waters: trends and prognosis (ICP Waters report 119/2015) (Oslo: Norwegian Institute for Water Research, 2015). Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

chemistry in 2020 were marginal compared with measured water chemistry in 2012, despite a considerable reduction in sulphur (S) deposition. The Task Force meeting applauded the presentation of the preliminary results and concluded that this report is likely to produce important results documenting relations between deposition, climate and expected chemical recovery of surface waters.

5. *Biodiversity* The outline for the 2015 ICP Waters report on biodiversity and climate was presented (item 1.1.15.b). The aim of the analysis is to separate effects of acidification and climate change, i.e. increased temperature and precipitation, on biodiversity of aquatic, bottom-dwelling organisms. Long time series of chemical and biological monitoring data in combination with climate data are used. A preliminary analysis indicates that diversity may be limited at very low pH, while at higher pH more variation is found. The Task Force expressed its appreciation of the presentation of the outline and acknowledged the unique database. The Task Force concluded that quantification of relationships between water chemistry and biodiversity will be an important contribution from ICP Waters to the work under the Convention. The Task Force also acknowledged that separating the effects of deposition and climate is a challenging task.

6. *Recovery of fish populations*: Salmon populations in Norway returned to a large extent as result of common efforts of international, regional and local policy. Salmon populations became extinct in southern Norway in the 1960s because of toxicity in surface waters resulting from acid deposition. International policy for abatement of atmospheric emissions went hand-in-hand with national and regional policy which resulted in a return of Atlantic salmon to rivers in South Norway. National and local policy consisted of liming to improve water quality, and stocking of water bodies with salmon, especially there were local fish populations became extinct. Local stakeholders stimulated positive developments of fish stocks by promoting awareness in the public and in politics.

7. *Biological and chemical recovery*: National Focal Centres presented trends in biological and chemical recovery from monitoring programmes in Canada, Finland, Sweden and the United Kingdom. Improvements in water chemistry, as a response to reduced atmospheric deposition, were widespread. Climatic variation was also shown to affect water chemical status in several lakes and rivers. Trends in biological recovery are less equivocal. In some lakes, calcium may become a limiting factor to sustain aquatic populations. The Task Force applauded the work done by the National Focal Centres, and emphasized the importance of national monitoring networks.

8. *Dissolved organic carbon:* Presentations from Task Force members from the Czech Republic and Sweden showed that dissolved organic carbon (DOC) levels affect surface water acidification, with implications for implementation of the European Union (EU) Water Framework Directive, water treatment works and for expected chemical recovery of surface waters. A follow-up of the 2007 paper on trends and spatial variation in DOC was announced. The National Focal centres agreed to extend the original data set from 2007, and to be involved in providing additional information on sites and provision of updates for chemistry. The Task Force is content with a renewed focus on DOC trends and applauds a follow-up of the 2007 Nature paper.

9. *Dynamic modelling:* Task Force members from the Czech Republic presented acidification history and recovery of acidified streams in the Czech Republic. These were shown to depend on model assumptions for leaching of dissolved organic carbon (DOC). Less recovery is predicted when taking into account increasing trends in DOC. Increased DOC has been demonstrated for most ICP Waters sites. The Task Force concluded that dynamic modelling gives useful insights for expected recovery of surface waters.

10. *Critical loads:* It was demonstrated that using national estimates or EMEP-modelled estimates of S and nitrogen (N) deposition results in different areas with critical load (CL) exceedance in Norway. Area exceeding CL is 3 per cent (in 2020) using EMEP-modelled deposition, instead of national estimates when exceedance is 9 per cent (in 2020). The most

likely reason for this discrepancy appeared to be that EMEP-modelled deposition in Norway was too low, as a comparison between modelled and measured deposition for Norwegian stations showed. Using EMEP or local (national) deposition data is important for the conclusion that is drawn with regard to the state of the acidification problem. The Task Force agreed that the conclusions of this presentation should be conveyed to EMEP and urge EMEP to consider how to address uncertainties and biases in EMEP deposition. In the following discussion it was stressed that non-exceedance of CLs does not indicate that acidification is no longer causing damage, but rather that sometime in the future, acidification will no longer be a problem.

11. *Parties in Eastern Europe, the Caucasus and Central Asia:* The National Focal Point from the Russian Federation presented case studies from European part of the Russian Federation and Siberia of acidification in humid regions. The presentation focused on mechanisms of surface water acidification. An assessment of the degree and geographic extent of acidification was given. Some acidified waters in the northern parts of the Kola Peninsula have recently recovered somewhat chemically (as manifested by increased alkalinity and pH), owing to reduced emissions of strong acids. Further south there are lakes that have become more acidic. Natural organic acids (humic substances) strongly affect the acidification/recovery process, especially in catchments with a high proportion of wetlands. The Task Force urged the ICP Waters Programme Centre to continue its efforts to further include Parties in that subregion in the activities of the Programme Centre.

12. *Chemical intercomparison:* Results from the twenty-eighth chemical intercomparison were reported.[5] Thirty-three laboratories from 12 countries participated. The quality of results was similar to that in former years. In total, 76 per cent of all results were acceptable. The chemical intercomparison is a valuable tool for quality assurance of laboratory analyses.

13. *Biological intercalibration:* Results from the seventeenth biological intercalibration of invertebrates were reported.[6] The goal was to evaluate the quality and harmonize the taxonomic work. Four laboratories participated and showed excellent taxonomic work. Ten laboratories have participated on a regular basis in the intercalibration.

14. *Participation in other groups under the Working Group on Effects:* Representatives of the ICP Waters Programme Centre participated in the meetings of the task forces of other International Cooperative Programmes (ICPs), i.e., the ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) and the ICP on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping), as well as the Joint Expert Group on Dynamic Modelling.

15. *Exploration of ways to combine activities of ICPs* The Task Force discussed a possible joint meeting with ICP Integrated Monitoring (item 1.8.3), and recommended that the Programme Centre should further explore this possibility.

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[5] Carlos Escudero-Oñate, *Intercomparison 1428: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn (ICP Waters report 120/2014)* (Oslo: Norwegian Institute for Water Research, 2014). Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

[6] Arne Fjellheim, Arne Johannessen and Torunn Svanevik Landås, *Biological intercalibration: Invertebrates 1713,* ICP Waters report 118/2014 (Oslo: Norwegian Institute for Water Research, 2014). Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

III. Workplan items common to all International Cooperative Programmes

A. Further implementation of the Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects (workplan item 1.1.10 (a))

16. An overview of the monitoring effects reported by ICP Waters, according to the Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects (ECE/EB.AIR/2008/11) was provided in ECE/EB.AIR/WG.1/2014/6.

B. Enhanced involvement of countries in Eastern and South-Eastern Europe, the Caucasus and Central Asia, and cooperation with activities outside the Convention (workplan item 1.1.10 (b))

17. With regard to the involvement of countries in Eastern and South-Eastern Europe, the Caucasus and Central Asia in ICP Waters work (workplan item 1.1.10 (b)), currently, Armenia, Belarus and the Russian Federation participate in ICP Waters activities (see para. 9 above). A paper on responses to air pollution of water chemistry of arctic lakes in the Kola region in the Russian Federation was published with lead authors from the Russian Federation in cooperation with the ICP Waters Programme Centre.[7]

C. Cooperation with programmes and activities outside the region (workplan item 1.1.10 (c))

18. There is currently no cooperation with programmes and activities outside the United Nations Economic Commission for Europe (ECE) region (workplan item 1.1.10 (c)).

D. Contribution to the joint annual report by the Working Group on Effects (workplan item 1.1.11)

19. ICP Waters contributed to the 2015 joint progress report on policy-relevant scientific findings to the Working Group on Strategies and Review and to the Executive Body (workplan item 1.1.11) (see ECE/EB.AIR/GE.1/2015/3-ECE/EB.AIR/WG.1/2015/3).

E. Fostering of integrated and thematic assessments (workplan item 1.8.1)

20. Regarding *fostering of integrated and thematic assessments* (workplan item 1.1.18), ICP Waters, together with others ICPs, contributed to the trend report of the Working Group on Effects,[8] and to the 2016 assessment report.[9] The Working Group on Effects trend report is coordinated by ICP Waters.

[7] Moiseenko TI, Dinu MI, Bazova MM, de Wit HA (2015) Long-Term Changes in the Water Chemistry of Arctic Lakes as a Response to Reduction of Air Pollution: Case Study in the Kola, Russia. Water Air and Soil Pollution 226(4): 12.

[8] See informal document N° 8 Draft Working Group on Effects report on trends.

[9] See informal document.

IV. Workplan items specific to the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes

A. Identification of the state of surface water ecosystems and their long-term changes (workplan item 1.1.15 (a))

21. Concerning the identification of the state of surface water ecosystems and their long-term changes with respect to regional variation and the impact of selected air pollutants, including effects on biota (workplan item 1.1.15 (a)), a trend analysis on chemistry and biology was done.[10] A trend analysis of surface water chemistry in acid-sensitive lakes and rivers in Europe and North America, for the period 2000 to 2011, was combined with a prognosis for water chemistry in Europe in 2020. Also, trends in freshwater biology in acidified surface waters in Europe were presented. Declining emissions and deposition of sulphur between 2000 and 2011 lowered sulphate concentrations in surface waters. The clearest indication that water chemistry is getting less hostile to acid sensitive organisms is increased pH. Several examples of partial biological recovery are presented, but also examples where communities of aquatic invertebrates show few signs of recovery. It is expected that climate variability will confound effects of reduced sulphur emissions on chemical and biological recovery in the next decades.

B. Identification of changes in biodiversity and climate in surface water ecosystems (workplan item 1.1.15 (b))

22. Work to identify changes in biodiversity and climate in surface water ecosystems (workplan item 1.1.15 (b)) is ongoing. An analysis will be presented in a report in 2015,[11] while a master thesis was delivered in July 2015.[12] A statistical analysis of long-term water chemistry, biology (sediment-dwelling aquatic biota; invertebrates) and climatic data from three acid-sensitive catchments at the west coast of Southern Norway was performed in the master thesis. The results show that invertebrate communities in rivers, but not in lakes, shifted from a state with low or absence of acid-sensitive taxa to an alternate state with higher richness and abundance of acid-sensitive taxa. Chemical recovery in lakes and rivers was similar, and related to reduced sulfur deposition. The recovery of invertebrate communities in rivers was primarily related to reduced sulfur deposition, and associated water chemistry. Superimposed on the long-term trends in the invertebrate communities, it is possible that temperature fluctuations and sea-salt episodes caused additional short-term variability. However, impacts of a temperature rise on the long-term invertebrate community trends were not identified. However, accelerated climate change predicted for the 21st century may result in unpredictable, and possibly abrupt, changes to an alternate state. The importance of a continuous research effort to disentangling the complex link between acidification, and climate on invertebrate community change is therefore stressed.

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[10] Garmo, Ø., H. de Wit, A. Fjellheim. Chemical and biological recovery in acid-sensitive waters: trends and prognosis (ICP Waters report 119/2015) (Oslo: Norwegian Institute for Water Research, 2015). Available from http://www.icp-waters.no/Publications/tabid/62/Default.aspx.

[11] Velle, G., et al., in preparation. ICP Waters report.

[12] Van der Lee, G., “Invertebrate community change in acidified rivers and lakes in Southern Norway”, Master thesis (GEO4-2321) - 30 ECTS, Master Sustainable Development, Faculty of Geosciences, Utrecht University, the Netherlands. Supervision K.T. Rebell (Utrecht University), H.A. de Wit, G. Velle, A. Fjellheim (ICP Waters).

V. Expected outcomes and deliverables over the next period and the longer term

23. Besides air pollution, climate is expected to affect biological recovery and diversity in surface waters. We will deliver a report on changes in biodiversity and climate in surface water ecosystems (workplan item 1.1.15 (b)).[13] Long-range transported mercury leaches from soils to surface waters and accumulates in aquatic biota. In 2016, the ICP Waters will deliver a report on mercury in the aquatic environment (draft 2016-2017 workplan item 1.1.1.14). On the longer term, the ICP Waters will present a report on the regional extent of lakes impacted by acidification (draft 2016-2017 workplan item 1.1.1.15).

VI. Policy relevant issues, findings and recommendations

24. *Salmon populations in Norway returned to a large extent as result of common efforts of international, regional and local policy* Salmon populations became extinct in southern Norway in the 1960s because of toxicity in surface waters resulting from acid deposition. International policy for abatement of atmospheric emissions went hand-in-hand with national and regional policy which resulted in a return of Atlantic salmon to rivers in South Norway. National and local policy consisted of liming to improve water quality, and stocking of water bodies with salmon. Local stakeholders stimulated positive developments of fish stocks by promoting awareness in the public and in politics.

25. *Chemical recovery*: Long-term records of water chemistry of surface waters in Canada, Finland, Sweden, and the UK demonstrate chemical recovery as a response to reduction in acid deposition. The long-term trends also demonstrate variation in water chemistry related to climate episodes with the potential to delay or set back chemical recovery. In many regions, the status of acidified sites is far from background water chemistry.

26. *Biological recovery* Long-term records of aquatic organisms in acid-sensitive waters with chemical recovery show mixed biological responses to improved water chemistry. In some water bodies, catchment-specific factors appear to dominate how biology responds. In general, biological recovery is much slower than chemical recovery.

27. *Dynamic modeling* Acidification history and recovery of acidified streams in the Czech Republic were shown to depend on model assumptions for leaching of dissolved organic carbon. Less recovery is predicted when taking into account increasing trends in DOC. Increased DOC has been demonstrated for most ICP Waters sites.

28. *Countries in Eastern Europe, the Caucasus and Central Asia* Acidified waters in the northern parts of the Kola Peninsula in the Russian Federation have recently shown chemical recovery owing to reduced atmospheric emissions of acidifying components. Dissolved organic carbon (humic substances) strongly affects the acidification/recovery process, especially in catchments with a high proportion of wetlands.

29. *Critical loads* Discrepancies between S and N deposition modelled by EMEP and national estimates of deposition in Norway, lead to a significant difference in estimated area exceeded by critical loads. Investigating causes for these discrepancies and increasing awareness about possible biases in EMEP deposition is important for effect-based work under the Convention.

[13] Velle, G., et al., in preparation. ICP Waters report.

VII. Issues for the attention and advice of other groups, task forces or subsidiary bodies, notably with regard to synergies and possible joint approaches or activities

30. The ICP Waters monitoring network currently consists of approximately 200 sites in acid-sensitive areas in 16 countries in Europe and North America. The rivers and lakes are sampled regularly under national monitoring programmes. The length of the data series is mostly between 15 and 25 years. Some sites have over 30 years of data. The data are frequently used in trend assessments. Effects-related work under the Convention could benefit from joint activities on trends in ecosystem responses between various bodies and groups under the Working Group on Effects.

31. *Exploration of ways to combine activities of ICPs* The Task Force discussed a possible joint meeting with ICP Integrated Monitoring (item 1.8.3), and recommended that the Programme Centre should further explore this possibility. In a dialogue with ICP Integrated Monitoring it was found that both Task Forces were positive with regard to having a joint meeting, and it is planned to be held in Norway in May 2016.

VIII. Relevant scientific findings: highlights

32. Highlights of scientific findings of ICP Waters are summarized in document ECE/EB.AIR/GE.1/2015/3–ECE/EB.AIR/WG.1/2015/3 and in section VI above.

IX. Publications

33. For a list of ICP Waters publications and references for the present report, reference is made to the ICP Waters website.[14]

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[14] See http://www.icp-waters.no/Publications/tabid/62/Default.aspx.