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

Working Group on Effects

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Progress in activities in 2014 and further development of effects-oriented activities

2014 joint progress report on the activities of the International Coordinated Programmes and the Joint Task Force on the Health Aspects of Air Pollution

Summary

At its twenty-seventh session in December 2009, the Executive Body for the Convention on Long-range Transboundary Air Pollution decided that the Working Group on Effects would prepare an annual review of the activities and the results of the International Cooperative Programmes (ICPs), the Joint Task Force on the Health Aspects of Air Pollution (Task Force on Health) and the Joint Expert Group on Dynamic Modelling (ECE/EB.AIR/99/Add.2, item 3.1).

The present report was drafted by the Extended Bureau of the Working Group (comprising the Bureau of the Working Group; the Chairs of the ICP task forces, the Task Force on Health and the Joint Expert Group on Dynamic Modelling; and representatives of the ICP programme centres) in cooperation with the secretariat. The review of activities is based on the information provided by the lead countries and the programme centres, and is submitted in accordance with the 2014–2015 workplan for the implementation of the Convention (ECE/EB.AIR/122/Add.2, items 1.1.10–1.1.11).

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I. Introduction

1. The present report highlights outcomes of the work under the Convention on Long-range Transboundary Air Pollution’s Working Group on Effects during the period 2013–2014 considered to be of interest for policy purposes. Through their strong networks and centres, the subsidiary bodies under the Working Group have been able to maintain their activities in spite of the economic crisis. In fact, the outputs from many of these subsidiary bodies have increased in recent years. This has been evident from the thematic reports produced by several International Cooperative Programmes (ICPs), but also, in particular, from the common integrated reports from the Working Group system. These reports have in general been directed towards well-identified societal needs, but also, in some cases, have been produced in response to direct requests from the Convention.

2. In 2013, two thematic reports were elaborated for the consideration of the Working Group:

(a) Heavy metals and nitrogen in mosses: spatial patterns in 2010/11 and long-term temporal trends (1990–2010) in Europe (ECE/EB.AIR/WG.1/2013/13), prepared by the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation);

(b) Benefits of air pollution control for biodiversity and ecosystem services (ECE/EB.AIR/WG.1/2013/14), a joint effort of several ICPs led by ICP Vegetation.

The reports were presented to the Executive Body to the Convention at its thirty-second session in December 2013.

3. In 2014, a strong focus has been on the compilation of a common thematic Working Group on Effects report on air pollution impacts on vegetation in countries of Eastern and South-Eastern Europe, the Caucasus and Central and South-East Asia (ECE/EB.AIR/WG.1/2014/13). A second thematic report focuses on the health impacts of and the policy options for residential heating with wood and coal (ECE/EB.AIR/WG.1/2014/14). Several of the other activities and results have received increased attention through brochures, which in several cases have been translated into Russian. In addition, a large number of scientific publications have been published on the adverse effects of air pollution, thus strengthening the scientific credibility of the effects-oriented work under the Convention.

4. The main highlights of the present report include:

(a) Air pollution is the largest environmental contributor to the global burden of disease throughout the United Nations Economic Commission for Europe (ECE) region; large data gaps make assessments uncertain and there is a great need to increase monitoring, in particular, in countries of Eastern Europe, the Caucasus and Central Asia;

(b) The Joint Task Force on the Health Aspects of Air Pollution (Task Force on Health) drew attention to the health effects of residential heating of wood and coal, and urged either switching from solid fuel heating to gas or electricity-based heating, or greatly improving the efficiency of home wood combustion devices;

(c) A new response function and a new critical level for ozone have been developed to be used in integrated assessment modelling in Europe;

(d) A web-based smartphone application has been developed for recording incidences of ozone-induced leaf damage on vegetation;

(e) A report on air pollution impacts on vegetation in Eastern and South-Eastern Europe, the Caucasus and Central Asia stresses the great need for the extension of networks for air pollution monitoring in those areas;

(f) A new common biodiversity indicator termed the “habitat suitability index”, which can complement the critical load approach in assessing air pollution effects, has been developed;

(g) Surveys of lichens in forest stands in Europe indicate an empirical critical load for nitrogen deposition on tree stems of 2.4 kilograms of nitrogen per hectare per year (kg N ha^{-1} y^{-1});

(h) Further moss surveys of heavy metals and other compounds will be organized in the future through an institute in the Russian Federation;

(i) Since 1987, corrosion of materials has decreased substantially and the magnitude of improvement is typically 50 per cent.

5. The working Group and its subsidiary bodies had followed with interest the process of the ICP review and welcomed the conclusions as presented at the thirty-second session of the Working Group in September 2013, and at the meeting of the Extended Bureau of the Working Group in March 2014. The Working Group will take the recommendations into account when planning its future work. In particular, the Working Group welcomes the recommendations on closer collaboration with the policy bodies under the Convention. At the same time, realization of some of the recommendations might be difficult due to limited financial resources.

6. Air pollution impacts are monitored within several of the ICPs and the participation by Parties in these activities continues to be high despite the financial constraints in many countries. The Clean Air Policy Package[1] recently presented by the European Commission includes an ongoing programme for monitoring of ecosystems effects in line with the programme under the Working Group. Several ICPs have also supported the further development of the Working Group’s programme by providing, inter alia, the definitions of parameters in line with the Working Group Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects, adopted by the Executive Body at its twenty-sixth session in December 2008 (ECE/EB.AIR/2008/11 and ECE/EB.AIR/WG.1/2008/16/Rev.1).

II. Selected key results

A. Impacts of air pollution on human health

7. *Health effects high on the agenda:* In recent years the overall scientific evidence on the health effects from air pollution has become compelling and the associated burden of disease is significant. Air pollution is the largest contributor to the burden of disease from the environment. The great majority of the population worldwide, including in Europe, is exposed to levels exceeding the WHO air quality guidelines.[2] However, there are data gaps, and ground-level monitoring remains very limited in countries in Eastern Europe, the Caucasus and Central Asia, with only a small number of monitoring stations.

8. *New figures on health effects on humans:* The latest evidence of the health impacts of air pollution was presented and discussed at the seventeenth meeting of the Task Force

[1] See http://ec.europa.eu/environment/air/clean_air_policy.htm.
[2] See http://www.euro.who.int/en/health-topics/environment-and-health/air-quality.

on Health in May 2014.[3] WHO estimates released in March 2014 showed that exposure to air pollution accounted for 7 million premature deaths worldwide in 2012, including almost 600,000 in the WHO European Region. Specifically, 482,000 deaths were attributed to ambient air pollution and 117,200 deaths to household air pollution in the WHO European Region. These deaths are due to ischemic heart disease, chronic obstructive pulmonary disease, lung cancer and acute lower respiratory infections. Exposure to air pollution is a more important risk factor for major non-communicable diseases (such as cardiovascular diseases) than previously thought.[4]

9. *Ambient air pollution classified as carcinogenic to humans:* In October 2013, the International Agency for Research on Cancer, a WHO specialized agency, announced that it classified outdoor air pollution, as well as particulate matter, as carcinogenic to humans. This ruling came after careful review by a group of experts of the evidence of cancer in humans and animals, as well as underlying biological mechanisms.[5]

10. *Air quality guidelines for indoor air quality under way:* Later in 2014, WHO plans to issue a new set of indoor air quality guidelines for household fuel combustion. They will provide guidance on policies and the impacts on health of various fuels and technologies (for cooking, heating and lighting). The guidelines include recommendations for emission rate targets in order to meet the WHO air quality guidelines for carbon monoxide and fine particular matter ($PM_{2.5}$). They also include recommendations for household energy transition from traditional and low emission biomass to clean fuel use. The guidelines recommend that unprocessed coal should not be used as a household fuel, and that household combustion of kerosene should be discouraged while further research into its health impacts is conducted.[6]

11. *Residential heating of wood and coal as a risk for public health:* A report on the health impacts of and the policy options for residential heating with wood and coal (ECE/EB.AIR/WG.1/2014/14) has been developed following a recommendation of the Task Force on Health made at its sixteenth meeting in June 2013. The report highlights the importance of residential biomass combustion for space heating as a major source of ambient $PM_{2.5}$ and black carbon across Europe (north and south) and in temperate forested countries on other continents. It emphasizes that it will be difficult to tackle outdoor air pollution problems in many parts of the world without reducing emissions from household heating with wood and coal. The report states that to protect health, there is a need for policymakers to create incentives for switching from solid fuel heating to gas- or electricity-based heating, or to greatly improve the efficiency of home wood combustion devices. Climate-oriented policies that advocate for wood combustion should promote only best available (lowest emission) technologies. An executive summary of the report will be submitted to the Executive Body to the Convention at its thirty-third session in December 2014. The full report will also be issued as a WHO publication.

12. *Further actions to reduce health risks can give large benefits at low cost:* The Task Force was also informed about the cost-effectiveness and cost-benefit analyses conducted under the Clean Air Policy Package. Modelled trends of pollutant levels show that under a business as usual scenario (baseline projection), the adverse impacts of air pollution will

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[3] See http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/activities/health-aspects-of-long-range-transboundary-air-pollution.
[4] See http://www.who.int/phe/health_topics/outdoorair/databases/en.
[5] See Dana Loomis and others, “The carcinogenicity of outdoor air pollution”, *The Lancet*, vol. 14, No. 13 (December 2013), pp. 1262–1263. Available from http://dx.doi.org/10.1016/S1470-2045(13)70487-X.
[6] WHO *Guidelines for indoor air quality: household fuel combustion* (in press).

continue to decrease by 2020, when they will amount to an estimated 340,000 premature deaths. The progress in further reducing the health impacts from air pollution is expected to be considerably slower beyond 2020. On average across Europe, the baseline projection suggests a decline in the loss of statistical life expectancy attributable to the exposure to $PM_{2.5}$ from 8.3 months in 2005 to 5.3 months in 2025. The results of the cost-benefit analysis show that moving from the baseline to the selected policy scenario would cost $US 4.6 billion per year, but would generate benefits between 12 and 42 times larger. These results provide solid justification for the selection of the policy scenario.

13. The role of the recent WHO reviews of air pollution health aspects — the “Review of evidence on health aspects of air pollution” (REVIHAAP)[7] and the “Health risks of air pollution in Europe” (HRAPIE)[8] projects conducted between 2011 and 2013 — was emphasized, as these reviews have been decisive in informing the policy choices as part of the revision of the EU air policy.[9]

14. Further activities are planned by WHO to raise awareness of air pollution health impacts with policymakers and to specifically target the health sector, since air pollution has not yet been included in the traditional non-communicable prevention strategies. This convincing evidence provides arguments for the need to take further action to reduce air pollutant emissions and to improve air quality.

15. *Expert meeting on methods and tools for assessing health risks at various scales:* An expert meeting was convened by the WHO in Bonn, Germany, on 12 and 13 May 2014, to discuss the data, methods and tools available for assessing the human health risks of air pollution at various geographic scales, including regions outside the Convention area. The meeting was intended to provide advice to a variety of health risk assessment efforts, including but not limited to the work of the Task Force on Health and the Task Force on Hemispheric Transport of Air Pollution. The discussions at the meeting focused on lessons to be learned from various recent research initiatives, including the Global Burden of Disease[10] project, as well as the REVIHAAP and HRAPIE projects. A report from the meeting is being developed and will be used as the starting point for a WHO publication for health risk assessment practitioners and policymakers on general principles for air pollution health risk assessment for various purposes and at various scales. The meeting was also a first step for further collaboration between the two Task Forces on assessments of air pollution health effects on a hemispheric scale.

16. *Need to expand monitoring and assessment activities in Eastern and South-Eastern Europe, the Caucasus and Central Asia:* As mentioned earlier, the Task Force on Health has identified a significant need to improve monitoring and assessment of air pollution in the Eastern parts of the ECE region. Some cities suffer from severe air pollution and better data on emissions and concentrations will support both health effects assessments and the elaboration of optimal control measures.

[7] See http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report.

[8] See http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/health-risks-of-air-pollution-in-europe-hrapie-project.-new-emerging-risks-to-health-from-air-pollution-results-from-the-survey-of-experts.

[9] Susann Henschel and Gabrielle Chan, *HRAPIE project*: *Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide* (Copenhagen: WHO Regional Office for Europe, 2013). Available from http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications.

[10] See http://www.who.int/topics/global_burden_of_disease/en/.

B. Effects of ozone on vegetation

17. *New response function and new critical level for integrated assessment modelling in Europe:* In order to use the ozone flux methods instead of the earlier concentration-based methods for integrated assessment modelling (IAM), a new simplified flux-effect relationship for ozone impacts on crops has been developed. The method is developed to be used for integrated assessment modelling only and should not be used for other situations, e.g., estimates of crop losses. The new crop flux approach provides an estimation of the worst case for damage to crops with adequate water supply either rain-fed or irrigated. Reductions in ozone flux associated with dry soils, such as those commonly found in the Mediterranean areas, are not included in this model and thus effects may be overestimated where irrigation is not used in those areas.

18. The new term for the simplified generic ozone flux is Phytotoxic Ozone Dose above an ozone flux threshold of 3 nmol m^{-2} s^{-1} (POD_3IAM) for a 90-day exposure period (based on wheat yield). The associated ozone critical level is 8 mmol m^{-2}. The new response function thus provides an indication of potential effects and associated critical levels for use in scenario analysis and optimization runs within the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model[11] on wheat yield under non-limiting water availability.

19. For other applications, including national and local effects estimates, it is recommended that the full wheat flux model is used. For the Mediterranean areas, the Mediterranean-specific parameterization should be used (as defined in the *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends*[12] (Modelling and Mapping Manual). New parameterizations based on the flux model for the crop species grapevine, maize, soybean and sunflower and for the poplar tree species have been included in the Modelling and Mapping Manual.

20. *Ozone damage smartphone application:* ICP Vegetation developed a web-based smartphone application for recording incidences of ozone-induced leaf damage on vegetation. The application will be tested by ozone experts in 2014 and is scheduled for release to the general public in 2015. The application will allow further collation of field-based evidence of ozone impacts on vegetation and the analysis of spatial patterns (in principal across the globe). ICP Vegetation has also published a leaflet on ozone injury symptoms, which is available in English and Russian.[13]

C. Effects on vegetation and ecosystems in countries in Eastern and South-Eastern Europe, the Caucasus and Central and South Asia

21. ICP Vegetation together with the ICP on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping) recently published the report, *Air pollution: Deposition to and impacts on vegetation in*

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[11] See http://gains.iiasa.ac.at/models/.

[12] Germany, Federal Environmental Agency (Berlin: December 2004). Available from http://www.icpmapping.org/Mapping_Manual.

[13] See http://icpvegetation.ceh.ac.uk/publications/documents/CEHOzoneInjury_webmidres.pdf and http://icpvegetation.ceh.ac.uk/publications/documents/Ozone_injury-leaflet-RUS-final.pdf .

(South-)East Europe, Caucasus, Central Asia and South-East Asia.[14] The report concludes that there are large risks for effects both from ozone and heavy metals in these regions. The areas with highest risk are in Eastern and South-Eastern Europe. The report highlights the lack of monitoring stations for air pollutant concentrations and deposition in these regions (particularly in countries of Eastern Europe, the Caucasus and Central and South-East Asia) in comparison with other regions in Europe (especially Northern, Western and Central Europe). In the same regions, there is also a lack of a coordinated network for monitoring air pollutant impacts on vegetation.

D. Heavy metals

22. The ICP Vegetation Task Force transferred the coordination of the European moss survey on heavy metals, nitrogen and persistent organic pollutants to the Russian Federation with the aim of enhancing participation from countries in Eastern and South-Eastern Europe, the Caucasus and Central Asia and potentially other Asian countries. The new coordination centre is based at the Joint Institute for Nuclear Research in Dubna. The next survey is scheduled for 2015–2016 and negotiations for participation are ongoing with the following countries (in addition to the Russian Federation): Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Republic of Moldova and Uzbekistan. Other Asian countries include China, India, Mongolia, Pakistan, Republic of Korea, Thailand and Vietnam.

23. Methyl mercury levels in freshwater fish in boreal areas (North America, Nordic countries) exceed limits advised for human consumption and are still of great concern in these areas. Recent studies from Canada and Sweden presented at the meeting of the Task Force of the ICP on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) confirm the exceedances and show that some fish species show significant increases in mercury content over time. Reductions in mercury emissions have so far not resulted in decline of mercury in fish. Factors driving present trends in methyl mercury in aquatic biota are hypothesized to be related to reduced sulphur deposition, increased concentrations of dissolved organic carbon and climate warming.

E. Impacts of nitrogen deposition on biodiversity and ecosystem process indicators

24. Biodiversity and ecosystem services are threatened by multiple pressures, including nitrogen pollution, climate change and resource consumption. The pressure from air pollution on biodiversity is still high and long-term impacts of nitrogen on biodiversity are likely to continue unless substantial future deposition reductions occur. Over recent years, the critical loads concept has been complemented by the concept of “no net loss of biodiversity” and ecosystem services. These concepts have been applied both for field studies under the ICP on Integrated Monitoring of Air Pollution Effects on Ecosystems Integrated Monitoring (ICP Integrated Monitoring) and under ICP Modelling and Mapping. However, the traditional critical loads concept will still play a central role.

25. In a recent study by the ICP on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) based on monitoring epiphytic lichens growing on tree stems, an empirical critical load of 2.4 kilograms of nitrogen per hectare per year (ha^{-1} y^{-1}) was found. At this comparatively low nitrogen deposition level, effects on epiphytic lichen seem to be

[14] Harry Harmens and Gina Mills (eds.), Bangor, United Kingdom: Centre for Ecology and Hydrology, March 2014. Available from http://icpvegetation.ceh.ac.uk/publications/documents/CEHOzoneReport2014_webhighres.pdf

one of the most sensitive parameters for the impact of nitrogen deposition. This leads to the conclusion that lichens cannot only be regarded as sensitive towards impacts from gaseous sulphur dioxide, but also to influences from nitrogen compounds dissolved in rain water.

26. ICP Integrated Monitoring studied the empirical evidence of the critical loads with respect to the forest floor vegetation response to nitrogen deposition in Europe. It was found that the cover of plant species, which prefer nutrient-poor soils (oligotrophic species), decreased the more the measured nitrogen deposition exceeded the empirical critical load for eutrophication effects. However, species preferring nutrient-rich sites (eutrophic species) did not experience a significant increase in cover. Contrary to species cover changes, the decrease of species richness did not correlate with the exceedance of critical loads. It was assumed that the lack of diversity changes resulted from the restricted time period of the observations.

27. The results from these two studies confirm the suitability of the use of the critical loads concept for eutrophication as used for assessment purposes.

F. New indicators for mapping areas at risk

28. For several years, there has been a challenge to find suitable indicators that can be used for mapping areas at risk and for integrated assessment modelling. Following the 2013–2014 call for data, ICP Modelling and Mapping made progress[15] with the development of a common biodiversity indicator termed the "habitat suitability index" that can extend the critical load approach. The new concept is tailored to:

(a) Be country-specific, but allowing transboundary comparisons of the (risk of) impacts;

(b) Meet impact assessment requirements as formulated in the Long-term Strategy for the Convention (see ECE/EB.AIR/106/Add.1).

29. Although further conceptual and methodological work is still needed, the indicator provides a metric for estimating the change of plant species caused by interactions between air pollution, climate change and other factors affecting changes in biodiversity (e.g., management).

30. ICP Modelling and Mapping seeks also to relate the "habitat suitability index" to indices with other policy relevant issues such as carbon sequestration. The focus of the current development of indicators is to improve knowledge to answer policy questions on, e.g., the trade-offs between:

(a) The increase of carbon sequestration and impacts of excessive nitrogen deposition including the (temporary?) increase in net ecosystem productivity;

(b) The decrease of carbon sequestration potential and impacts of excessive ozone concentrations caused by the insufficient abatement of nitrogen oxides;

(c) Decreasing marginal carbon sequestration potential and soil chemical imbalances possibly caused by long-term exceedance of critical loads of nutrient nitrogen.

[15] Including research performed in components 4 and 5 of the "Effects of climate change on air pollution impacts and response strategies for European ecosystems" (ECLAIRE) project. See http://www.eclaire-fp7.eu/.

G. Effects on materials

31. Monitoring of air pollution effects to materials over 25 years shows large improvements in corrosion. Under the ICP on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) evaluation of trends was concentrated on a few policy-relevant questions, with answers based on corrosion of carbon steel, zinc, copper and limestone (1987–2012) and soiling of modern glass (2005–2012). The main outcomes of this evaluation are:

(a) Since 1987 corrosion of all materials has decreased substantially and the magnitude of the decrease varies from site to site and depending on material but is typically 50 per cent. Some improvements can be observed since the year 2000, for example, for carbon steel, but these improvements are minor;

(b) The importance of sulphur dioxide for corrosion has decreased substantially over the period studied but it still plays some role. Nitric acid and particulate matter (including black carbon) are still of great importance for corrosion and soiling of materials and cultural heritage. Wet acid deposition is of less importance, but is still significant for corrosion of some materials and in some locations. Functions developed for the multi-pollutant situation can predict corrosion only to some degree;

(c) Corrosion and soiling is still above the 2020 target for a few sites and above the 2050 target for even more sites, and the exceedances are occurring at the most polluted sites;

(d) For polluted areas, with no significant influence of chloride deposition, climate change will result in increased corrosion in the north and decreased corrosion in the south, and if pollution is constant. This will require stronger demands on air quality standards for Northern Europe related to corrosion. The magnitude of the effect is very uncertain, and present estimates are depending on the scenario used for climate change. Climate change will not affect the risk for soiling, but one of the main important parameters, black carbon, is also a short-lived climate forcer;

(e) Estimation of corrosion costs at five United Nations Educational, Scientific and Cultural Organization (UNESCO) cultural heritage sites across Europe[16] shows that actual corrosion due to air pollution would result in material deterioration costs ranging from €9.2 per square metre per year (m^{-2} $year^{-1}$) to €43.8 m^{-2} $year^{-1}$, depending on the status of the material, the pollution level and the climatic conditions. These costs add to the cost in background areas, estimated from €14 m^{-2} $year^{-1}$ to €28 m^{-2} $year^{-1}$. Cost estimates are, however, subject to uncertainty due to the assumption in estimating lifetimes of materials and the cost of the interventions. At current air concentrations, sulphur dioxide is no longer the dominant factor for the degradation of these selected monuments. Nitric acid and particulate matter seem to play a prominent role in determining corrosion damage of limestone. In developing future actions for protecting historical and cultural monuments like the UNESCO cultural heritage sites, it would be important to consider the reduction of atmospheric nitric acid and particulate matter with a size less than or equal to 10 microns in diameter concentrations.

[16] Paris, France (banks of the Seine); Prague, Czech Republic (National Library); Berlin, Germany (Neues Museum); Bath, United Kingdom of Great Britain and Northern Ireland (Royal Crescent); Greece, Athens (the Parthenon).

Figure 1

Carbon steel corrosion (in micrometres (µm)) after one year of exposure at two selected sites in the ICP Materials network: Kopisty, Czech Republic, and Aspvreten, Sweden