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Recent results and updating of scientific and technical knowledge

2012 joint progress report on the activities of the International Coordinated Programmes, the Joint Task Force on the Health Aspects of Air Pollution and the Joint Expert Group on Dynamic Modelling

Summary

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

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; representatives of the programme centres of ICPs; and invited experts) 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 Convention's 2012–2013 workplan (ECE/EB.AIR/109/Add.2, item 3.1 (b)).

Contents

I. Introduction

1. This report is a brief summary of achievements during 2011–2012 within the following International Coordinated Programmes (ICPs) under the Working Group on Effects: the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters), the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials), the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation), the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring), the International Cooperative Programme on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping), the joint Task Force on Health Aspects of Air Pollution of the World Health Organization (WHO)/European Centre for Environment and Health (ECEH) and the Executive Body of the Convention on Long-range Transboundary Air Pollution (Task Force on Health) and the Joint Expert Group on Dynamic Modelling (JEG). More detailed information from ICPs is available in their 2012 technical reports; however, these reports are available in English only following the decision of the Extended Bureau of the Working Group on Effects at its meeting in February 2012.

2. This report contains in particular evaluations of recent developments of ecosystem effects (exceedances of critical loads, chemical and biological effects) in relation to present emission reductions and expected further reductions due to the revision of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) to the Convention on Long-range Transboundary Air Pollution for 2020 and beyond; studies on ozone’s effects on food security and carbon sequestration; studies on heavy metal budgets; and, finally, recent progress on air pollution effects on materials.

II. Outcome of the revision of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and scenarios for additional emission control

3. The emissions in 2020 under the Revised Gothenburg Protocol (RGP2020), as foreseen at the thirtieth session of the Executive Body for the Convention (30 April–4 May 2012) were applied by the ICP Modelling and Mapping and the Coordination Centre for Effects (CCE) to calculate exceedances of critical loads for acidification and eutrophication and presented to the forty-first session of the Task Force on Integrated Assessment Modelling, held at Bilthoven, the Netherlands, from 7 to 9 May 2012.

4. Fulfilling the objectives of RGP2020 will lead to overall reductions in environmental impacts compared to 2010, but a lot remains to be done, especially with regard to nitrogen. The ecosystem area where critical loads for acidification is exceeded, will decrease from 9.3% in 2005 to 4.2% in 2020. For eutrophication, it will decrease from 51% to 42% in 2020. A preliminary analysis for a subset of the ecosystems shows a reduction of the nature area with more than 5% biodiversity loss — from 8.4% to 3.3% in 2020. It is noted that the analysis of the 2020 Current Legislation scenario (see CCE Status

Report 2011[1]) yields an area at risk of acidification, eutrophication and loss of biodiversity of 37% (5% more protected in comparison to RGP2020), 4% (0.2% more protection) and 3% (0.3% more protection), respectively. To achieve protection from acidification and eutrophication in all ecosystems in Europe, RGP2020 emissions of total nitrogen and sulphur would have to be reduced equitably over Europe by at least 70%.

5. CCE has also looked at Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) domain emissions per country area (km^{-2}) , per capita (cap^{-1}) and as per gross domestic product (GDP) ($€^{-1}$). A comparison between these measures shows large differences between countries: emissions per km^{-2} of sulphur (S) dioxide (SO_2) and total nitrogen (N) range from about 0 t S km^{-2}–4 t S km^{-2} (top six country emissions > 1 t S km^{-2}) and 0–9 t N km^{-2} (top 19 country emissions > 1 t N km^{-2}), respectively. Per capita, the ranges vary between 1 kg S cap^{-1}–29 kg S cap^{-1} (top 7 country emissions > 10 kg S cap^{-1}) and 5 kg N cap^{-1}–26 kg N cap^{-1} (top 19 > kg N cap^{-1}) respectively. Finally, sulphur and total nitrogen emissions per GDP turn out to range between 0 g S $€^{-1}$–14 g S $€^{-1}$ (top 11 country emissions > 1 g S $€^{-1}$) and 0 g N $€^{-1}$–9 g N $€^{-1}$ (top 10 country emissions > 1 g N $€^{-1}$). CCE will continue to investigate the impacts of equitable emission reductions. Work on aspirational long-term emission reduction targets indicates how large the deposition reduction needs to be to virtually eliminate negative environmental impacts. First results indicate that for acidification, a 50%–60% reduction in acid deposition will leave less than 1% of the ecosystem area with critical load exceedances.

6. CCE has in addition made an analysis of the outcome of the European Union (EU) National Emission Ceilings Directive[2] based on the 2001 data (EMEP Lagrangian model and critical loads of 1998) with respect to exceedance of critical loads for acidification and eutrophication. First results tentatively show that the National Emission Ceilings Directive is largely met based on these data. However, when using more recent data (critical loads of 2008 and the EMEP Eulerian model) corresponding computations indicate that 2010 targets will be more difficult to reach.

7. Effects of further emission reductions and climate change on critical loads and their exceedances were assessed for 108 intensive ICP Forests monitoring plots in 17 countries. For a selection of 77 of these plots, the Very Simple Dynamic Model (VSD+; CCE Status Report 2009) was applied to provide estimates of future development of forest soil chemistry. Results show widespread soil acidification in the year 1980 with nearly 60% of the plots affected by critical loads exceedances. A continued positive future development until 2020 is clearly visible, leading to a full protection of forest under the assumption of the most ambitious air pollution abatement scenario. In contrast, a maximum feasible emission reduction scenario would still leave 10% of the forest sites unprotected against nitrogen effects by the year 2020. Full implementation of existing EU clean air legislation would result in 20% of the forest sites being unprotected. The ongoing nitrogen deposition results in continued eutrophication, as indicated by further decreasing carbon-to-nitrogen (C/N) ratios in soil solution until 2050. An analysis of the geographical distribution of effects shows that eutrophication is not limited to single regions, but is a widespread phenomenon across the forest plots in Europe. The results also indicate that climate change (Intergovernmental Panel on Climate Change (IPCC) scenario A1B) may increase sensitivity towards inputs of nitrogen. The reason is that temperature increase will lead to reduced nitrogen immobilization in the soil.

[1] ftp://ftp.rivm.nl/cce/outgoing/Web/pdfs/Publications/2011.pdf

[2] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.

8. Data from ICP Integrated Monitoring sites provide a link between modelled critical loads and empirical measurements, and thus an indication of the applicability of critical load estimates for ecosystems. Critical loads for acidification and eutrophication and their exceedances were determined for 18–37 ICP Integrated Monitoring sites depending on data availability. The level of protection of these sites with respect to acidifying and eutrophying deposition was estimated for the years 2000 and 2020 for different deposition scenarios derived from the EMEP/Meteorological Synthesizing Centre-West (MSC-W) unified atmospheric dispersion model. In 2020, more sites will be protected from acidification (67%) than in 2000 (61%). However, due to the sensitivity of the sites, even the maximum technically feasible emission reductions scenario would not protect all sites from acidification. In 2000, around 20% of the Integrated Monitoring sites were protected from eutrophication. In 2020, under current emission reduction scenarios, about one third to half of the sites would be protected, from eutrophication.

9. Across the ICP Integrated Monitoring sites, there was a good correlation between the exceedance of critical loads for acidification and key acidification parameters in run-off water, both with annual mean fluxes and concentrations. There was also evidence of a link between exceedances of critical loads of nutrient nitrogen and nitrogen leaching. Furthermore, long-term changes in vegetation seem to be related to the exceedance of the critical loads of nitrogen at the sites. However, these relationships are complex and are currently subject to further studies. The collected empirical data of ICP Integrated Monitoring thus allows testing and validation of key concepts used in the critical load calculations. This increases confidence in the European scale critical loads mapping used in integrated assessment modelling.

10. ICP Waters has used the dynamic model MAGIC to evaluate the effects of future deposition scenarios: COB2020 (current legislation), Low*2020, Mid*2020, High*2020, and MFR2020 (maximum technically feasible reduction) on surface waters. These five deposition scenarios are very similar to one another and represent substantial decreases in deposition for the year 2020 relative to the base year 2000. At all sites the modelled results indicate that chemical recovery will continue. At all but the most acid-sensitive sites acid neutralizing capacity (ANC) will increase to levels above the critical level for biological damage. Additional improvements in water quality can be obtained in the future with emission reductions beyond MFR2020.

III. Selected key results

A. Impacts of particulate matter on health

11. Over 80% of population in the European Region of WHO lives in cities with levels of coarse particulate matter (PM_{10}) exceeding *WHO Air Quality Guidelines for Europe*.[3] This estimate is based on air quality monitoring data available from 33 out of 53 member States (357 cities). A slightly decreasing trend of PM_{10} levels has been observed in EU countries over the last decade, but no significant improvement of average levels of PM_{10} was noted. New data from cities in Albania and Uzbekistan, where the monitoring started in 2010/11, confirm that urban air pollution may also be a significant problem in places where no PM_{10} monitoring is currently conducted. This pollution creates a substantial burden of disease, reducing life expectancy by almost nine months on average in Europe. New approaches to the assessment of population exposure to fine particulate matter ($PM_{2.5}$),

[3] WHO Regional Publications, European Series, No. 91 (Copenhagen, 2000). Available from http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf.

based on improved atmospheric modelling and remote sensing, are being developed and will be applied to burden of disease assessment expected to be published later in 2012.

12. Following the request of the Executive Body, the Task Force on Health evaluated the health risks of black carbon (BC) as a component of particulate matter (PM(. The Task Force concluded that BC is associated with both short- and long-term health effects, and that the reduction of $PM_{2.5}$ containing BC should lead to a reduction of health effects associated with PM. However, in view of insufficient evidence on the differences between the effects of BC and fine particulate matter measured as $PM_{2.5}$ mass, continuation of the use of $PM_{2.5}$ as the primary metric in quantifying human exposure to PM is recommended.

13. The Task Force on Health also reviewed the evidence on health effects of wildfires (wild and prescribed forest fires, tropical deforestation fires, peat fires, agricultural burning and grass fires). The daily averaged emissions of $PM_{2.5}$ from landscape fires (~7.5 ktons/day) in Europe have been assessed as being nearly as large as the similarly averaged total $PM_{2.5}$ emissions (~9 ktons/day) from registered anthropogenic sources in 2006–2008. The smoke from landscape fires increases daily $PM_{2.5}$ concentrations in areas up to 500 km–1000 km from the fire by five to twentyfold. The hourly peak concentrations can rise to hundreds of $\mu g/m^3$ or even up to 1 mg/m^3–2 mg/m^3 in the affected areas. The burden of disease attributed to PM from wildfires has been estimated to amount to 12,800 (range 11,600–22,700) premature deaths per year.

B. Sulphur and nitrogen ecosystem budgets

14. Annual input-output budgets for sulphur and nitrogen compounds have been calculated for 17 ICP Integrated Monitoring sites across Europe to quantify long-term changes in retention processes of the deposition. The results show that, for bulk deposition, nitrate plus ammonia deposition generally clearly exceeds sulphur deposition on an equivalent basis, confirming the increasing relative importance of nitrogen deposition. Estimated sulphate budgets show a release of previously stored sulphate at most sites, particularly after 2000, indicating that forest soils now release previously accumulated sulphur. In contrast to sulphur, deposited nitrogen still shows strong retention at the Integrated Monitoring sites. The retention of inorganic nitrogen generally ranged between 90% to 97%. However, previous studies at ICP Integrated Monitoring sites have shown that sites with higher nitrogen deposition and lower C/N ratios in soils clearly show higher nitrogen output fluxes, indicating increasing risks of eutrophication and acidification effects during these circumstances. Work is currently in progress to quantify complete nitrogen budgets, including organic nitrogen forms, and nitrogen effect indicators at these sites, as well as statistical trend analysis of the results.

15. Progress made in dynamic modelling of surface water acidity by JEG has resulted in the development of assessment tools (such as the MAGIC library in Sweden and the United Kingdom of Great Britain and Northern Ireland), which have been applied in regional studies (e.g., in Finland, Sweden, the United Kingdom, Norway and the United States of America). These tools provide stakeholders with the ability to make site-specific, regional or national management or policy decisions in response to air pollution issues. The models show that recovery from acidification may take decades even after emissions have been reduced to a level below critical loads.

C. Effects on forests from nitrogen deposition and exposure

16. For assessing effects of nitrogen deposition on the nutrition of trees, the exceedances of critical limits in the soils were calculated. Up to 251 ICP Forests Level II plots were

included in the study, depending on data availability. Deposition data included throughfall and bulk deposition. For different soil depths annual mean concentrations and their exceedances of critical limits published in the scientific literature were assessed. Results show a clear relation between nitrogen deposition and the occurrence of high nitrate concentrations below the rooting zone indicating nitrogen saturation at the particular sites. Nutrient imbalances related to high nitrate concentrations were substantiated. Magnesium deficiencies occur more frequently on coniferous plots, with exceedances of critical limits for nitrate in the soil solution and the share of trees with light green to yellow discolouration higher when critical limits for nutrient imbalances are exceeded.

D. Impacts of ozone pollution on food security in Europe

17. In collaboration with EMEP/MSC-W, ICP Vegetation reported that economic losses due to ozone effects on wheat and tomato yield were estimated to be €3.2 billion and €1.0 billion respectively in the 27 countries of the (EU-27) plus Norway and Switzerland in 2000, based on modelling ozone uptake.[4] Implementation of a current legislation scenario (CLE2020) scenario was predicted to reduce these losses to €2.0 and €0.6 billion in 2020 for wheat and tomato respectively. Ozone effects were biggest in the main bread wheat growing areas in central and Northern Europe, where climatic conditions are highly conducive to ozone flux. Although ozone effects were predicted to reduce in 2020, exceedance of the flux-based critical level for wheat representing a 5% reduction in grain yield was only decreased from 85% of EMEP grid squares in 2000 to 82% in 2020. Thus, precursor emission reductions in addition to those included in the NAT scenario would be necessary before there was a substantial reduction in exceedance. Further details can be found in ICP Vegetation’s 2011 report on Effects of Air Pollution on Natural Vegetation and Crops (ECE/EB.AIR/WG.1/2011/8).

E. Ozone and carbon sequestration in living tree biomass

18. In collaboration with EMEP/MSC-W, ICP Vegetation estimated the impacts of ambient ozone on carbon storage in the living biomass of trees for the year 2000 and 2040 based on modelling ozone uptake (stomatal ozone flux, phytotoxic ozone dose) by trees.[5]

19. When applying a standard parameterization for deciduous and conifer trees, current ambient ground-level ozone was estimated to reduce carbon sequestration in the living biomass of trees by 12.0% to 16.2% (depending on ozone, meteorological and climate input data) in the EU-27 plus Norway and Switzerland in 2000. The flux-based approach indicated the highest ozone impact on forests in central Europe, where moderate ozone concentrations coincide with a climate highly conducive to high stomatal ozone fluxes and with high forest carbon stocks. A considerable reduction was also calculated for parts of Northern Europe, especially when applying climate region-specific parameterizations. The concentration-based approach (AOT40)[6] predicted substantially lower reductions in carbon storage (ca. 8% in the year 2000) than the flux-based approach, apart from in the Mediterranean.

[4] G. Mills and H. Harmens (eds.), “Ozone pollution: A hidden threat to food security”, report prepared by the ICP Vegetation Programme Coordination Centre (Centre for Ecology & Hydrology, Bangor, United Kingdom, 2011).

[5] H. Harmens and G. Mills (eds.), “Ozone pollution: Impacts on carbon sequestration in Europe” , report prepared by the ICP Vegetation Programme Coordination Centre (Centre for Ecology & Hydrology, Bangor, United Kingdom, 2012).

[6] Accumulated ozone concentration above a threshold of 40 ppb.

20. Under drought-free conditions (i.e., no limitation of soil water availability for tree growth), the predicted reduction in carbon sequestration in the living biomass of trees increased from 12.0% to 17.3% in the year 2000, with the highest reductions predicted for the warmer and drier climates in the southern half of Europe, particularly in the Mediterranean.

21. Although a decline in stomatal ozone flux was predicted in 2040, carbon sequestration in the living biomass of trees will still be reduced by 12.6% (compared with 16.2% in 2000). In 2040, the reduction in carbon sequestration was predicted to be considerably higher for the flux-based than the concentration-based (2.1%) approach.

22. The above results only describe ozone effects on the living biomass of trees and do not take into account any effect of ozone on soil carbon cycling, impacts of potential changes of forest management in the future or feedbacks to the climate system. Although the flux-response functions used were derived for young trees (up to 10 years of age), there is scientific evidence from some epidemiological studies that the functions are applicable to mature trees as assumed in this study. There is a clear need to include the impacts of ozone on vegetation in global climate change modelling.

F. Forest carbon budget

23. In another study conducted by ICP Forests, the carbon budget of 28 selected ICP Forests Level II plots was simulated for 1990–2009 and 2080–2099 (A1B scenario) using Biome-BGC model (version ZALF).[7] Data of the ICP Forests Level II database were used for model initialization and calibration. Compared with the reference scenario, the increase of carbon stocks accelerates by 47% for vegetation and by 17% for leaf+fine root litter pools. In contrast, the increase is diminished for coarse woody debris, and the decrease is accelerated for soil organic carbon. The carbon fluxes were simulated to be accelerated on average by +35% for Gross Primary Production and +26% for Net Ecosystem Production.

G. Heavy metal budgets

24. Heavy metal budget calculations carried out at ICP Integrated Monitoring sites indicate effective retention of mercury, lead and cadmium in soils for most of the catchments. The outflow of mercury (Hg) was 10%–20% of throughfall deposition at four Swedish Integrated Monitoring sites and, during the industrialization period, the pool of Hg in soils has been greatly increased by human activities. Because of the long turnover time in soils (centuries) there is no direct link between current Hg deposition and leaching to waters. The transfer of Hg to freshwater fish from soil systems is, however, a major concern due to direct human health issues, and detailed work on Hg processes is currently ongoing within ICP Integrated Monitoring and JEG. In the three countries that have carried out critical load calculations for Hg using Hg in fish as an indicator as part of ICP Mapping and Modelling activities, exceedance in 97%–100% of the area was reported. Forestry operations have been especially highlighted as a source of increased Hg input.

H. Biodiversity

25. There has been a progress in modelling of nitrogen cycling in terrestrial ecosystems with the focus on the links between nitrogen, biodiversity and climate change. An example

[7] http://www.zalf.de/en/forschung/institute/lsa/forschung/oekomod/biomebgc/Pages/default.aspx.

of such effort is the work using data collected by ICP Forests together with JEG for evaluating the VSD+ and BERN[8] models. The adaptability of presently existing vegetation to future site conditions was calculated assuming a deposition scenario with full implementation of current national emission legislation in all countries of the EU. Results suggest that vegetation is fully adapted to present site conditions on 10 out of the 20 plots studied. On 13 plots the "regeneration ability" is assumed to remain unchanged under the deposition scenario applied. On four plots it is assumed to decrease until 2050, and on three plots there are indications for an increased "regeneration ability". For eight plots, changes in main tree species are recommended.

26. Another example of recent progress in modelling the biological response to changes in soil and climate properties is using the MultiMOVE model,[9] which is an ensemble of three statistical models of species occurrence each applied to over 1,500 species in the United Kingdom. These models allow prediction of individual species occurrence, along with associated levels of uncertainty, for any given combination of nitrogen enrichment, acidity, climate and management intensity. The models provide the ability to examine the interactive effects of air pollution and other environmental drivers on biodiversity, and are now being developed to set habitat and species-specific critical thresholds for nutrient nitrogen. This approach provides the potential for robust, empirically based linking of air pollution drivers and biodiversity responses. In the last two calls for data issued by CCE, an effort has been made to bring national habitat experts together with the national modelling experts responsible for critical load calculations to focus on impacts at NATURA 2000 sites, thus encouraging much-needed interactions between modelling experts contributing to the work of Working Group on Effects and habitat experts.

27. ICP Waters has initiated a comprehensive analysis of its 25 years of data in order to search for factors controlling biodiversity and also to map temporal trends in biodiversity from the late 1980's until the present. The primary objectives are to: (a) find a suitable measure of biodiversity for the ICP Waters data; (b) calculate the biodiversity using this suitable measure; (c) search for trends in biodiversity among sites; and (d) examine the biodiversity in light of the external chemical stressors, such as changes in the impact of air pollution and climate change. Biological and chemical monitoring data collected within the ICP Waters programme are now being analysed to assess the development and trajectory of the ecosystems during the past 25 years. The data includes several million entries of benthic invertebrates and water chemistry from streams and lakes in Norway, Sweden, Germany, Latvia and the United Kingdom. Preliminary results show a gradual increase in biodiversity at most sites from the mid-1980s until about the late 1990s. This amelioration is likely a recovery caused by reduced deposition of acidifying compounds, and especially sulphate, in surface waters. The biological response and recovery lags behind the chemical recovery, as is typically seen in biological systems. From the turn of the millennium, the biodiversity first levelled out and then started to decrease towards the present. Even if decreasing biodiversity is not seen at all sites, it still seems to be a widespread phenomenon. It is not straightforward to interpret the decreasing trend. It may be linked to a long-term depletion of base cations in the catchments in combination with human-induced stressors, such as climate change, habitat alteration and input of nutrients.

[8] A. Schlutow and P. Hubener, "The BERN Model: Bioindication for Ecosystem Regeneration towards Natural conditions", Research report 20085221, (German Federal Environment Agency, 2004).

[9] J. B. Latour and R. Reiling, "A multiple stress model for vegetation ('move'): a tool for scenario studies and standard-setting". *Science of the Total Environment*, vol. 134 (1993), pp. 1513–1526.

IV. Air pollution effects on materials — corrosion is decreasing

28. ICP Materials has investigated trends in corrosion and pollution since 1987 and trends in soiling since 2005. For corrosion, three indicator materials have been selected to represent the different responses to the environment that materials can have: carbon steel, zinc and limestone. During the first 10 years of measurement (1987–1997), the measured corrosion of all three materials decreased substantially. The magnitude of the decrease varied slightly depending on material and location, but the average number was generally close to a 50% decrease for this 10-year period.

29. After this 10-year period, roughly coinciding with the turn of the century, the three indicator materials did not respond in the same way to improvements in the environment. Carbon steel corrosion has continued to decrease at the same pace, while zinc corrosion and limestone recession are no longer decreasing. Carbon steel is particularly sensitive to SO_2 pollution.

30. Corrosion trends of the same materials have also been evaluated by means of dose-response functions and environmental data from the different scenarios prepared for the revision of the Gothenburg Protocol. When comparing measured and calculated values, the conclusion is that the actual decrease in corrosion will not be as substantial as predicted by the maps for 2020.

31. In addition to the normal characterization of SO_2, nitrogen dioxide, ozone and PM, as part of the measurement programme aiming at understanding the relationship between environment and corrosion and possible explanations for discrepancies between measured and calculated corrosion values, ICP Materials is measuring outdoor concentrations of nitric acid since 2002 and, for the period 2011–2012, also outdoor concentrations of formic and acetic acid. This will be a unique dataset potentially useful not only for corrosion research.

32. Soiling of materials has not decreased since 2005 and this mode of degradation is closely linked to deposition of BC.

33. Currently, ICP Materials is conducting a pilot study involving United Nations Educational, Scientific and Cultural Organization sites, aiming at mapping the environment in the vicinity of the objects, estimating exposed surfaces and, in the end, estimating associated costs of corrosion due to pollution. Sites include the Acropolis (the Parthenon), in Athens, the façades in the centre of Paris and the National Library in Prague.