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Recent results and updating of scientific and technical knowledge

Effects of Air Pollution on Materials

Report by the Programme Coordinating Centre of the International Cooperative Programme on Materials, including Historic and Cultural Monuments

I. Introduction

1. The work of the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) in 2010 covered corrosion and soiling in the period 2008–2009; validity of dose-response functions for different climatic conditions; economic evaluation of corrosion of materials including cultural heritage; and combined stock at risk and mapping. The results are presented here in accordance with item 3.2 of the 2010 workplan for the implementation of the Convention (ECE/EB.AIR/99/Add.2), adopted by the Executive Body at its twenty-seventh session in December 2009.

II. Workplan items common to all programmes

A. Targets and ex post application

2. ICP Materials has specified targets for protecting infrastructure and cultural heritage for 2020 and 2050 (see ECE/EB.AIR/WG.1/2009/16). For corrosion, targets are given for three indicator materials (carbon steel, zinc and limestone). For soiling, no material-specific target was yet available.

3. For soiling, a simplified analysis based on available dose-response functions for limestone, painted steel and plastic has been carried out. It resulted in the following expression: target soiling dose = time x PM10 = 200 ± 20 year µg m^3. For the 2020 target, time is 10 years and results in a PM10 target of 20 µg m^3. For the 2050 target, time is 20 years and results in a PM10 target of 10 µg m^3.

4. For corrosion, the 2020 targets correspond to 2.5 times current background levels. The 2050 targets they correspond to 2 times current background levels. Currently, all scenario-independent parameters have been prepared and are available on the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) grid of 50 km x 50 km. The scenario-dependent variables, i.e., air pollutant concentrations, are not yet delivered.

B. Robustness

5. Robustness of dose-response functions and measured corrosion effects have already been reported on, including the experimental and random error for corrosion (see ECE/EB.AIR/WG.1/2007/3) and soiling parameters (see ECE/EB.AIR/WG.1/2008/3). Possible systematic errors are reported in section IV.B.

C. Links with biodiversity

6. The work of ICP Materials is not directly related to biological diversity, although its work touches on that subject in two different ways. First, there are indirect effects on the environment, for example those caused by metal run-off from roofs. Those effects have been calculated for copper (see ECE/EB.AIR/WG.1/2006/3) and zinc (see ECE/EB.AIR/WG.1/2008/3). Data are not available to perform similar analyses for other relevant metals. The second way biological diversity is relevant to ICP Materials work is as part of the broader concept “human health/human well-being”, where human well-being is determined not only by biological diversity but also other factors, in particular by cultural heritage. ICP Materials has contributed on that aspect of materials degradation in the book “The Effects of Air Pollution on Cultural Heritage”, published in 2009.[1]

D. Trends in selected monitored/modelled parameters

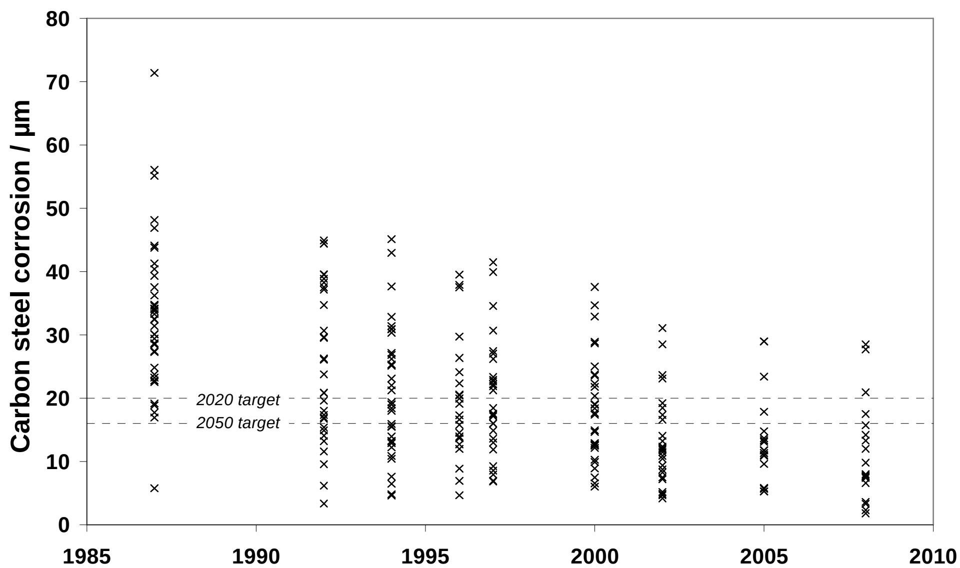
7. ICP Materials exposes materials and measures key parameters every three years in a “trend exposure”. The results prior to the 2008–2009 exposure have already been reported (see ECE/EB.AIR/WG.1/2008/3). The first soiling and corrosion results from the period 2008–2009 have become available. They have enabled the updating of trends for carbon steel, one of the key parameters in annex II of the Guidelines on reporting of monitoring and modelling of air pollution effects (see figure 1). The results indicated a significant corrosion decrease at ICP Materials test sites. Additional actions are needed in order to meet the 2020 and 2050 targets as there were no substantial changes in corrosion compared with the exposures in 2005–2006 and 2008–2009.

[1] Watt, J.; Tidblad, J.; Kucera, V.; Hamilton, R. (Eds.), *The Effects of Air Pollution on Cultural Heritage* (New York, Springer Science and Business Media, New York, 2009).

Figure 1

Carbon steel corrosion in the period 1987–2008 measured at ICP Materials test sites

(Dashed lines indicate targets for protecting infrastructure and cultural heritage for 2020 and 2050 (see ECE/EB.AIR/WG.1/2009/16)



III. Particulate matter

8. Soiling of modern glass and Teflon filter was part of the field exposure in the period 2008–2009. The soiling was evaluated by the amount of total deposited particles, haze and reflectance. The exposure was the second one-year exposure of soiling materials. The first was in the period 2005–2006, and recent data enabled a first evaluation of soiling trends. For haze, which is the most suitable parameter for evaluation of soiling, 23 per cent of the sites had an increasing trend, 41 per cent no trend and 36 per cent a decreasing trend.

IV. Cross-cutting issues

A. Report on corrosion and soiling for the period 2008–2009

9. During the period 2008–2009, corrosion of carbon steel continued to decrease, but the decrease was not very substantial. The 2008-2009 exposure showed that three cities — Kopisty, Czech Republic; Bottrop, Germany; and Katowice, Poland — had carbon steel corrosion values above the 2020 target (20 µm) (see also figure 1).

10. There was no obvious trend in the corrosion of zinc. In the recent exposure five sites showed zinc corrosion values above the 2020 target (1.1 µm). Corrosion rates of zinc at some of these sites were higher than expected from the measured pollution level. However, results from analysis of corrosion products on zinc showed high levels of acetate. Future measurement should include measurements of organic acids and/or their precursors, which could be a possible new confounding factor for corrosion.

11. As for zinc, there was no obvious trend in the corrosion of limestone and in the recent exposure 11 sites showed limestone corrosion values above the 2020 target (8 µm). In the 2005–2006 exposure there had been a suspicion that the characteristics of the particular stone batch observed had resulted in higher corrosion rates than expected. A comparison of different stone materials has shown that that was not the explanation. It was concluded that, similarly to zinc, the results from the 2005–2006 exposure were unusually high and part of the natural year–to-year variation in climate-dependent corrosion.

B. Report on validity of dose-response functions for different climatic conditions

12. ICP Materials have developed dose-response functions for a situation dominated by sulphur dioxide and a multi-pollutant one, based on corrosion, pollution and climate data from the temperate climate zone, mainly Europe. With the expected global climate change and targets developed for 2050, when those changes can be substantial, it is important to verify the robustness of dose-response functions for different climatic conditions.

13. ICP Materials currently compiles independent data, i.e., data not used in the development of the functions, from Europe, Asia, Africa and Latin America. A preliminary analysis has been made of a separate data set including data from Asia and Africa. Observed and predicted values were compared for three materials; zinc, copper and limestone. The observed values were on the average 0.8 times smaller than expected for zinc. The observed values were 1.5 times higher than expected for copper and 2.4 times for limestone. It is possible to estimate the robustness of functions based on independent data and that the error can be substantial for some materials.

C. Report on economic evaluation of corrosion of materials including cultural heritage

14. The total amount of stock at risk varied from about 50 to 130 m^2 per capita depending on country. This generally included the whole outer envelope of buildings (roofs and walls) and in some cases also parts of the infrastructure. In most studies no distinction was made for cultural heritage buildings. Further work in 2010 will report the material-specific variation in cost per surface area and the variation in total cost per capita, depending on the study and/or country.

D. Report on combined stock at risk and mapping for Italy at the national level

15. A valuation of the effect of air pollution on the Italian cultural heritage at national level will be completed by the end of 2010. The spatial data for the 100,050 outdoor cultural monuments indicate that they are relatively uniformly distributed, although there are concentrations in some cities such as Rome, Florence and Venice. The monuments were divided in five groups based on their material composition: archaeological areas; castles and fortresses; ecclesiastic buildings and churches; palaces and villas; and sculptures. Dose-response functions will be used to calculate corrosion maps, using EMEP 50 km x 50 km grid data on pollutant concentrations in 2007 and proximity of industrial areas and heavy traffic.