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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

Ninth joint session
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Item 9 (b) (i) of the provisional agenda
Progress in activities in 2023 and further development of effects-oriented activities: air pollution effects on materials, the environment and crops: air pollution effects on materials

Effects of air pollution on materials

Progress report by the Programme Coordinating Centre of the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments

Summary

The present report by the Programme Coordinating Centre of the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) under the Working Group on Effects presents the results of the activities undertaken by ICP Materials between May 2022 and May 2023. The activities and the report thereon are presented in accordance with the 2022−2023 workplan for the implementation of the Convention (ECE/EB.AIR/2021/2, table 1, items 1.1.1.9 −1.1.1.10) and with the revised mandate for ICP Materials (Executive Body decision 2019/19)[a].

The Programme Coordinating Centre report presents the results of the thirty-ninth ICP Materials Task Force meeting (Bochum, 3−4 May 2023). It describes trends for environment, corrosion and soiling during the period 1978-2021, including results from the recently completed trend exposure 2017-2021, and summarizes the status of the call for data and future plans on inventory and condition of stock of materials at risk at United Nations Educational, Scientific and Cultural Organization World Cultural Heritage Sites.

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

I. Introduction and overview of deliverables

1. The present report by the Programme Coordinating Centre for the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) describes the activities carried out by ICP Materials between May 2022 and May 2023. It highlights the results of activities undertaken since its previous report (ECE/EB.AIR/GE.1/2022/13−ECE/EB.AIR/WG.1/2022/6), submitted to the eighth 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 (Geneva, 12-16 September 2022). The results are presented here in accordance with the 2022−2023 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/2021/2).

2. ICP Materials is co-chaired by Mr. Johan Tidblad (Sweden) and Ms. Teresa La Torretta (Italy), with Mr. Tidblad also acting as the head of the ICP Materials Programme Coordinating Centre. Participating in the work of ICP Materials are nearly 30 experts from the following 17 countries: Austria, Croatia, Czechia, Estonia, Finland, France, Germany, Greece, Italy, Norway, Poland, Slovakia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland, and United States of America.

3. The thirty-ninth meeting of the ICP Materials Task Force (Bochum, 3-4 May 2023) was attended by 25 participants from 13 countries, including the Chair of the Working Group on Effects and representatives from the secretariat of the Convention on Long-range Transboundary Air Pollution.

4. During 2022, the following reports were delivered: “Results on corrosion and soiling from the 2017–2021 exposure programme for trend analysis”;[1] and “Call for data “Inventory and condition of stock materials at UNESCO world cultural heritage sites”. Part VI – The relationship between the environment and the artefact”[2].

5. In 2023, the following ICP Materials reports are expected: “Environmental data report”; and “Report of trends in corrosion, soiling and pollution 1987-2021”; and “Application of models with increased resolution in the study of damage at selected UNESCO sites – Switzerland”.

II. Workplan items common to all International Cooperative Programmes

A. Guidelines for reporting on the monitoring and modelling of air pollution effects

6. The guidelines for reporting on the monitoring and modelling of air pollution effects (ECE/EB.AIR/2008/11−ECE/EB.AIR/WG.1/2008/16/Rev.1)[3] specify that, for effects of particulate matter on materials, the degree of soiling should be reported, and for multiple pollutant effects on materials, the corrosion of indicator materials (carbon steel, zinc and limestone) should be reported. This is part of the ongoing activities of ICP Materials (for exposure of materials for trend analysis, see section III.A below).

[1] ICP Materials, Report No. 92 (Kista, Sweden, Research Institutes of Sweden (RISE), 2022). Available at www.ri.se/sites/default/files/2022-12/Report-92-Trend-exposure_2017-2021.pdf

[2] ICP Materials, Report No. 93 (Bologna, National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), 2022). Available at www.ri.se/sites/default/files/2022-12/Report-93_UNESCO_Part_6_0.pdf

[3] Approved by the Executive Body for the Convention on Long-range Transboundary Air Pollution at its twenty-sixth session (Geneva, 15–18 December 2008) (ECE/EB.AIR/96/Add.1, decision 2008/1, para. 1).

B. Efforts to enhance the involvement of countries of Eastern Europe, the Caucasus and Central Asia

7. Discussions are being held on a continuous basis but countries of Eastern Europe, the Caucasus and Central Asia do not currently actively participate in ICP Materials work.

C. Cooperation with programmes and activities outside the region

8. ICP Materials and its experts collaborate regarding international standardization work in the field of atmospheric corrosion, specifically the International Organization for Standardization Technical Committee 156 - Corrosion of metals and alloys and European Committee for Standardization Technical Committee 346 - Conservation of cultural heritage. A current activity related to the work of ICP Materials is the preparation of an International Organization for Standardization Standard on procedures for mapping corrosion.

III. Workplan items specific to the International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments

A. Corrosion and soiling of selected materials under different environmental conditions

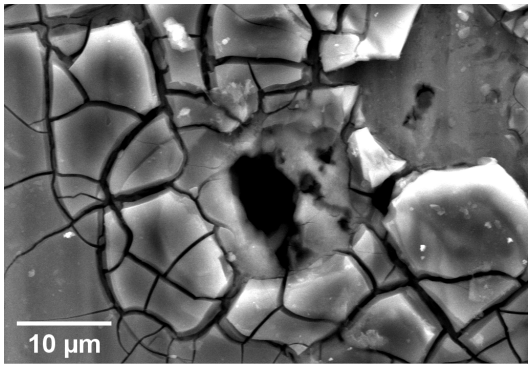
9. Exposures for trend analysis are performed every third year in the network of ICP Materials test sites. The completed exposure (2017−2021) included corrosion samples of carbon steel, stainless steel, weathering steel, zinc & titanium-zinc, aluminium, limestone and soiling samples of modern glass, limestone, marble, and coil-coated materials. The data were included in the "Results of corrosion and soiling from the 2017–2021 exposure programme for trend analysis".[4]

10. In summary, when looking at observed trends, corrosion and pollution have decreased significantly since the early 1990s and a shift in the magnitude was generally observed around 1997 from a sharp decrease to a more modest decrease or to a constant level without any decrease. Sulfur dioxide levels and corrosion have decreased even after 1997, a trend that is more pronounced in urban areas. When looking at the 4-year values of aluminium corrosion, for example, there is a significant decrease after 1990. The latest trend exposure (2017-2021) however, resulted in values approximately within the same range as the trend exposure 2011-2014. Nevertheless, the nature of the corrosion process in aluminium imposes challenges in the determination of the corrosion rate, especially in low concentration of pollutants scenarios, as the attack is localized in small areas (so-called pits), see Figure 1 below. One of the important pollutants for the formation of these pits is particulate matter (PM). PM might initiate the formation of pits in aluminium, by either acidifying the surface water film or retaining moisture for longer periods of time, among other mechanisms. For projected trends, the existing dose-response function for aluminium corrosion should be adapted to account for the localized corrosion phenomena, as well as the effect of particulate matter.

[4] ICP Materials, Report No. 92 (Kista, Sweden, Research Institutes of Sweden (RISE), 2022). Available at www.ri.se/sites/default/files/2022-12/Report-92-Trend-exposure_2017-2021.pdf

Figure 1

Initial localized corrosion (pit) surrounded by corrosion products, of an aluminium specimen from the 4-year exposure (2017-2021) corresponding to the site in Bottrop, Germany.



Source: Alice Moya Núñez, RISE Research Institutes of Sweden, Kista, Sweden.

B. United Nations Educational, Scientific and Cultural Organization World Cultural Heritage Sites

11. ICP Materials continues to gather and process information on policy-relevant and user-friendly indicators on the effects of air pollution on materials. These activities are currently conducted within the scope of the call for data on inventory and condition of stock of materials at risk at United Nations Educational, Scientific and Cultural Organization (UNESCO) world cultural heritage sites launched in October 2015 and involving six Parties to the Convention: Croatia, Germany, Italy, Norway, Sweden, and Switzerland.

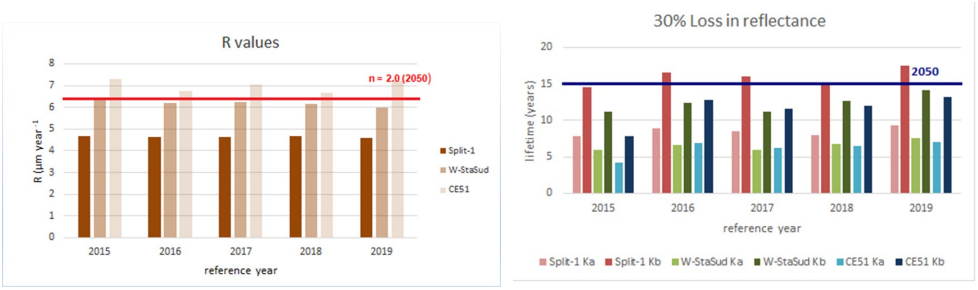
12. ICP Materials Report No. 93[5] concerns the study of the relationship between the environmental context surrounding some selected UNESCO sites and the air pollution responsible for the corrosion and soiling effects of the material. The three sites included in the study are: Saint Domnius, Split in Croatia, Würzburg Residence, Bavaria, Germany and Royal Palace, Caserta, Italy. They have been chosen based on maintenance cost due to air pollution.

13. Dose-response functions developed by ICP Materials was used to estimate the effect of atmospheric pollutants on limestone surface recession and soiling at the selected UNESCO sites. Even though a slight decrease in NO_2 and PM_{10} concentrations was observed in all cities that host these three UNESCO sites for the investigated years (2015-2019), a trend was not observed for surface recession (R) and relative loss of reflectance ($\Delta R/Ro$) (see Figure 2 below). Despite the decrease in emissions in recent years and the slight decrease in the concentrations of atmospheric pollutants, the studied cultural object materials continue to be partly at risk of corrosion and soiling. To reduce the risks that threaten our cultural heritage and consequently increase the economic cost of maintenance, further air pollution mitigation actions are needed to control emission sources.

[5] ICP Materials, Report No. 93 (Bologna, National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), 2022). Available at www.ri.se/sites/default/files/2022-12/Report-93_UNESCO_Part_6_0.pdf

Figure 2

Summary of surface recession and 30% loss in reflectance for the investigated three sites



Source: Teresa La Torretta, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Bologna.

14. The thirty-ninth meeting of the ICP Materials Task Force discussed application of models with increased resolution for assessing damage at selected UNESCO sites located in Switzerland. The results will be presented in ICP Materials Report No. 96 expected later in 2023.

IV. Messages for the attention of other bodies

15. A new update of the mapping manual, including soiling for the first time, has been released in 2022. It includes dose-response functions for transparent (glass), as well as non-transparent materials (painted steel, white plastic and polycarbonate membrane).

16. Updated trends in corrosion, soiling and pollution will be presented in 2023. Particulate matter is presently the pollutant that requires most attention; particles might play an important role for the initiation of pits in i.a. aluminium as well as increasing soiling of materials.

17. ICP Materials continues to gather and process information on policy-relevant and user-friendly indicators on the effects of air pollution on materials. This activity is carried out within the scope of the call for data on inventory and condition of stock of materials at risk at UNESCO world cultural heritage sites launched in October 2015 and involves six Parties to the Convention: Croatia, Germany, Italy, Norway, Sweden and Switzerland. In total, about thirty monuments have been studied withing the framework of the Call for data. Risk factors (pollutants) for different risks to materials constituting the artefacts have been identified (2018), as well as the annual cost of damage attributable to air pollution (2019) and the relative importance of individual pollutants and the effect of their reduction on the damage cost (2020) and the effect of increasing resolution of air quality model on estimating the damage of materials (2021), the relationship between the environment and the artefact (2022). Application of models with increased resolution for the study of damage at selected UNESCO sites located in Switzerland is expected in 2023.