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Working Group on Effects

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Progress in activities in 2019 and further development of effects-oriented activities

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 for 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 2018 and May 2019. The activities and the report thereon are presented in accordance with the request of the Executive Body to the Convention on Long-range Transboundary Air Pollution contained in its 2018–2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1).

The report of ICP Materials presents the results of its thirty-fifth Task Force meeting (Paris, 24–26 April 2019). It describes trends and results for corrosion and soiling from the recently completed trend exposure 2017–2018 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.

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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 2018 and May 2019. It highlights the results of activities undertaken since its previous report (ECE/EB.AIR/GE.1/2018/13−ECE/EB.AIR/WG.1/2018/6), submitted to the fourth 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 (Geneva, 10−14 September 2018). The results are presented here in accordance with the 2018−2019 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/140/Add.1).

2. ICP Materials is co-chaired by Mr. Johan Tidblad (Sweden) and Mr. Pasquale Spezzano (Italy), with Mr. Tidblad also acting as the head of the ICP Materials Programme Coordinating Centre. Participating in the work of ICP Materials are some 30 experts from the following 18 countries: Austria, Croatia, Czechia, Estonia, Finland, France, Germany, Greece, Italy, Norway, Poland, Russian Federation, Slovakia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland and United States of America.

3. The thirty-fifth meeting of the ICP Materials Task Force (Paris, 24−26 April 2019) was attended by 21 participants from 11 countries and the Chair of the Working Group on Effects.

4. During 2018, the following reports were delivered: "Call for Data 'Inventory and condition of stock of materials at UNESCO world cultural heritage sites'. Part II – Risk assessment"[1] and "Technical Manual for the trend exposure programme 2017–2018".[2]

5. In 2019, the following ICP Materials reports are expected: "Call for data on inventory and condition of stock materials at the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Cultural Heritage sites. Part III-Economic evaluation" and "Report on corrosion and soiling data from the 2017−2018 exposure for trend analysis".

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

1 International Cooperative Programme on Effects of Air Pollution on Materials, including Historic and Cultural Monuments (ICP Materials) Report No. 83 (Rome, National Agency for New Technologies, Energy and Sustainable Economic Development, 2018). Available at www.corr-institute.se/icp-materials/web/page.aspx?refid=18.

2 ICP Materials Report No. 84 (Kista, Sweden, Research Institutes of Sweden - Corrosion and Metals Research Institute, 2018). Available at www.corr-institute.se/icp-materials/web/page.aspx?refid=18.

3 Adopted by the Executive Body for the Convention at its twenty-sixth session in December 2008 (ECE/EB.AIR/96/Add.1, decision 2008/1).

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 chapter III.A below).

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, in particular in the context of 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 workplan item related to the work of ICP Materials is the preparation of a new International Organization for Standardization technical report 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 (2017−2018) included corrosion samples of carbon steel, stainless steel, weathering steel, zinc, copper, limestone and soiling samples of modern glass, limestone, marble and coil-coated materials. The data will be included in the "Report on corrosion and soiling data from the 2017−2018 exposure for trend analysis". The addition of new soiling samples is in line with the long-term strategy to increase focus on soiling materials and effects of particulate matter.

Figure

New samples for soiling: left-hand photograph - marble (top) and limestone (bottom); right-hand photograph - light and dark coil coated samples. Reproduced with permission of A. Verney-Carron, LISA (left) and T. Vuorio, HAMK (right)

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

10. In line with the 2018–2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1), 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 UNESCO world cultural heritage sites launched in October 2015 and involve six Parties to the Convention: Croatia, Germany, Italy, Norway, Sweden and Switzerland. The potential risk of damage (corrosion and soiling) due to air pollution to the materials of which twenty-one unique cultural objects are made was assessed by using dose-response functions established by ICP Materials. Results were compiled in a report (ICP Materials Report No 83).[4]

11. The main risk factors (pollutants) for the different risks (corrosion/soiling) are summarized in the table below. Fine particulate matter with a diameter of 10 micrometres or less (PM_{10}) was identified as a risk factor both for corrosion and soiling of limestone, while nitric acid (HNO_3) was identified as a risk factor only for corrosion. The combined effect of sulphur dioxide (SO_2) and ozone (O_3) was identified as a risk factor for copper, and PM_{10} and nitrogen dioxide (NO_2) were identified as risk factors for soiling of glass. SO_2 is still an important deterioration agent for some materials used in cultural heritage but is no longer the dominant factor. Furthermore, the acidity of precipitations seems to have only a limited impact on the degradation of materials in the current situation.

[4] See footnote 1.

Table
Risk factors (pollutants) for different risks to materials constituting the artefacts

Risk	SO_2	NO_2	HNO_3	SO_2*O_3	PM_{10}	*pH*
Limestone corrosion	+/++	-	++/+++	-	++	+
Sandstone corrosion	+/++	-	-	-	-	+
Copper corrosion	-	-	-	++/+++	-	+
Bronze corrosion	+	-	-	-	++	+
Limestone soiling	-	-	-	-	+++	-
Glass soiling	+/++	++/+++	-	-	++/+++	-

Abbreviations: SO_2, sulphur dioxide; NO_2, nitrogen dioxide; HNO_3, nitric acid; O_3, ozone; PM_{10}, fine particulate matter with a diameter of 10 micrometres or less.

Note: + indicates low impact; ++ indicates medium impact; +++ indicates high impact); - indicates that the specific risk/pollutant combination was not included in the used dose-response function. Therefore, the impact level could not be estimated.

12. At current concentrations of air pollutants, recession of limestone, corrosion of copper and soiling of both non-transparent (limestone) and transparent (glass) artefacts could be an issue for several historic and cultural monuments. The estimated recession rate of limestone and the estimated corrosion rate of copper after one year of exposure were well above the background corrosion rate (3.2 micrometres per year (µm year-1) for limestone and 0.32 µm year-1 for copper) and generally close to the target set by ICP Materials for the year 2050 (twice the background corrosion rate) or even higher. In some cases, these values are close to the targets set for 2020 (2.5 times the background corrosion rate). Soiling of limestone and glass artefacts appears to be unacceptably high.

13. At the thirty-fifth meeting of the ICP Materials Task Force (Paris, 24–26 April 2019) the evaluation of the expected cost of the damage due to air pollution was discussed. On the basis of preliminary data, the annual cost of damage attributable to air pollution under current conditions for the twenty-one cultural objects assessed in the call for data ranges, depending on the pollution level and the meteoclimatic conditions, from €3.1 to €20 per square metre of surface per year (m-2 year-1) for the recession of limestone, from €5.1 to €9.8 m-2 year-1 for the corrosion of copper, from €0 to €52.1 m-2 year-1 for the soiling of limestone surfaces and from €0 to €11.7 m-2 year-1 for the soiling of glass. These costs add to the cost in background areas, estimated at €4.4 m-2 year-1, €3.5 m-2 year-1,
€25 m-2 year-1 and €6.8 m-2 year-1, respectively, for limestone recession, copper corrosion, limestone soiling and glass soiling.

IV. Messages for the attention of other bodies

14. The 2017–2018 exposure for trend analysis has been successfully completed. The addition of new soiling samples is in line with the long-term strategy to increase focus on soiling materials and effects of particulate matter.

15. 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. 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).