ICP Materials

Progress of activities in 2023 and future work

Ninth Joint Session of the EMEP Steering Body and the Working Group on Effects
11 – 15 September 2023
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• Progress of current work plan items
• Trends in corrosion, soiling and pollution 1987–2021
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• Invitation to the next ICP Materials Meeting 2024
2022–2023 workplan for the implementation of the Convention

• 1.1.1.9 Impact of corrosion and soiling including trends
  – Report of corrosion and soiling data from the exposure for trend analysis 2017-2021 (2022) – Completed
  – Environmental data report October 2020 to December 2021 (2023) – Completed, short summary

• 1.1.1.10 Policy-relevant user-friendly indicators (UNESCO sites)
  – Report on Call for Data – Part VI: Study on the relationship between the environmental and the artefact on selected UNESCO sites (2022) – Completed, short summary
  – Report on Call for Data – Part VII: Application of models with increased resolution on selected UNESCO sites (2023) – Completed, short summary
Environmental data report (2023)
October 2020 to December 2021

| Table 4: No of 26 participating stations reporting environmental data parameters. |
|-----------------|------------------|------------------|
| Parameter       | 2018-19 and 2019-20 | 2020-21          |
| T (°C)          | 24                | 26               |
| RH (%)          | 24                | 24               |
| Precipitation amount (mm) | 23                | 24               |
| SO₂ (µg/m³)     | 24                |                  |
| NO₂ (µg/m³)     | 25                |                  |
| O₃ (µg/m³)      | 24                |                  |
| HNO₃ (µg/m³)    | 23                |                  |
| H⁺ in prec. (pH) |                  | 17               |
| Cl⁻ in prec. (mgCl/l) |               | 16               |
| Passive particle deposition (µg cm⁻² month⁻¹) | 22                |                  |
| PM₁₀ (µg/m³)    | 18                |                  |

Conclusions
The database obtained during the trend exposure period 2020-2021 has a similar regularity and quality as the previous years of the ICP Materials programme. Sites belonging to the national surveillance programmes and EMEP, have the best regularity. Some of the urban sites have a lower regularity. Except the overall missing data from two station (nos. 41 and 58) and the missing data for the precipitation quality (pH and Cl⁻) from several stations, the data coverage is good. The spread in the data for the different environmental parameters is sufficient for statistical dose response analyses.

• Database of corrosion, soiling and environment compiled
  – Report of corrosion and soiling data from the exposure for trend analysis 2017-2021 (2022)
  – Environmental data report October 2020 to December 2021 (2023)

• Main results for Trends in corrosion, soiling and pollution 1987-2021
Aluminum exposure: 2017-2021

- Aluminum experiments show corrosion in localized attacks. After pickling, the five deepest pits were measured from a 25x25 mm square.
Aluminum Trends: 1987-2021

- Decreasing trend in yearly corrosion for all sites.
- Pit depth might be a more appropriate variable to describe local corrosion in aluminum.

Mass loss four year exposure for 3 periods.

Localized corrosion attack in aluminum samples
Aluminum Trends: 1987-2021

- Multilinear regression: Correlation of pit depth and environmental variables.

Predicted versus observed pit depth (data from two 4-year exposures).

- Linear regression: No clear correlation between PM concentration and pit depth (average of five deepest pits).

- Objective: develop models using other environmental variables.

Variables: PM10, precipitation, NO2, O3
Equation of model:
pit depth = 17.2047 - 0.000675762*mm - 0.0465096*O3 + 0.0281917*NO2 + 0.00731376*PM10
Low quality prediction ($R^2 \sim 18\%$). More data points are needed to improve prediction models.
Stainless Steel: 1987-2021

Example of pitting corrosion after 4 years exposure at atmospheric test site 41 Berlin (effect of chloride deposition)
Corrosion losses have decreased with the exception of site 26 (Aspvreten).

The decreasing trend is less drastic for test sites 3 (Kopisty), 10 (Bottrop), 41 (Berlin) and 44 (Svanvik).
Modern Glass Trends 1987-2021

- Haze is stable or varies without clear trends in most sites.
- Site 13 (Rome) and 58 (New Haven) show a decrease in haze.
- Site 16 (Venice) and 53 (Vienna) show a slight increase in haze.
Dose-response functions for trend materials: Zinc example

\[ ML = 1.82 + t(1.71 + 0.471[SO_2]^{0.22}e^{0.018R}ef(T) + 0.041Rain[H+] + 1.37[HNO_3]) \]

\[ R^2 = 0.23 \]

\[ \text{New } ML = 5.36 + t(0.23*SO_2 + 0.0023*Rain + 0.04*Cl + 0.04*pH) \]

\[ R^2=0.81 \]

The influence of air pollutants (SO\textsubscript{2}) have decreased so that natural factors like temperature, rel. humidity and rain become more important for the corrosion process.

**A revision of the DRFs for trend materials is needed. Efforts will be made to develop functions without pH since this data is difficult to obtain.**
Coil-coated materials: dose-response

- Loss of reflectance for white painted steel (WPS) related to PM10 concentration and time (Mapping Manual $\Delta R = R_0[1 - e^{-3.96\times10^{-6}[PM10]t}]$)
- Calculation does not correlate with measured values in coil coated samples.
- More reliable PM measurements are needed (probably closer to the rack).
2024-2025 Workplan
Impact of corrosion and soiling including trends

<table>
<thead>
<tr>
<th>1.1.1.9</th>
<th>Monitor and assess impact on environment of corrosion and soiling effects on materials and their trends</th>
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<tr>
<td></td>
<td>Report on dose-response functions for trend materials (2024)</td>
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<td>ICP Materials</td>
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<td>Recommended contributions</td>
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<td>Technical manual for 2024–2025 exposure for trend analysis (2025)</td>
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</table>
39th meeting
May 3-5, 2023

Bochum and the German mining Museum! Finally!

There were total of 25 participants from 13 countries, including the chair of the working group on effects
ICP Materials Meeting 2024

Welcome to CENIM (Centro Nacional de Investigaciones Metalúrgicas)

6th-8th May 2024

Madrid, Spain
Call for data “Inventory and condition of materials at UNESCO world heritage sites”. Part VI. Study on the relationship between the environment and the artefact on selected UNESCO sites.
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 is investigated. Three different sites were chosen on the basis of their different estimated cost due to air pollution for the materials of the monuments.

<table>
<thead>
<tr>
<th>Site</th>
<th>Limestone (corrosion)</th>
<th>Limestone (soiling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Domnius Cathedral</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Würzburg Residence</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Royal Palace of Caserta</td>
<td>Very High</td>
<td>High/Very High</td>
</tr>
</tbody>
</table>

Range time investigated: years 2015-2019

To assess the damage due to attack of atmospheric pollutants at the selected UNESCO world cultural heritage sites, the methodology based on the use of dose-response function was used to estimate limestone surface recession and soiling.
Total emissions: decreasing

NO₂ and PM₁₀ concentrations: light decreasing.

Not observed a real trend for R and ΔR/R₀ (more or less same values in 2015-2019)

R values below 2050 target (6.4 µm year⁻¹) except for Caserta

Years number to reach 30% loss of reflectance increasing but far from 2050 target (15 years) except for Split considering the lower value for soiling K

Despite the decrease in emissions in recent years and the slight decrease in the concentrations of atmospheric pollutants, the materials of the cultural objects studied are still partly at risk
Part VII (2023): Application of models with increased resolution in the study of damage at selected UNESCO sites - Switzerland [work in progress]

Application of air quality models with increased resolution at selected UNESCO sites in Switzerland to assess the damage on materials due to air pollution

**EMEP01 with resolution 01° x 01°long-lat (9x11 km at 40°N)**

**Swiss national models with higher resolutions 100x100m ÷ 1000x1000m**

Old City of Berne, Abbey of St Gall, Benedictine Convent of St John at Müstair and Three Castles, Defensive Wall and Ramparts of the Market-Town of Bellinzona.
The recession rates modelled with national input maps are higher than those based on EMEP01 maps (around 20%).
Air pollutant concentrations are not elevated for the selected Swiss UNESCO sites investigated:
  • the recession values are below 2050 target (6.4 µm year-1)
  • number of years to reach 30% loss of reflectance is above or very close to 2050 target of 15 years before action.

Looking at all the maps:
  • the colour red/orange highlights the places with high buildings density and with traffic roads

The concentration of a pollutant calculated in a cell of a grid represents the mean value of the concentration of that pollutant in the whole area of that cell.
The reducing of the area of the cell improves the estimation of the concentration value of a pollutant in the zone of interest.

The major evidence of this study is that using a model with a resolution at urban scale it can have more realistic estimation of the effect of air pollutants on cultural object.
2024-2025 Workplan
Policy-relevant user-friendly indicators (UNESCO sites)

<table>
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<tr>
<th>1.1.1.10</th>
<th>Gather information on policy-relevant user-friendly indicators to evaluate air pollution effects on materials by conducting case studies on UNESCO cultural heritage sites</th>
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<tr>
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<td>Risk assessment for selected monuments based on retrospective trends in 2000, 2010 and 2020 and EMEP 01° x 01° data (2024)</td>
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