Air Quality Assessment in Cultural Heritage Locations by Dosimetry

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Introduction – Air Pollution in CH

The evaluation of the environment and the risk assessment for the preventive conservation of cultural heritage objects are complex exercises.

✓ IAQ Study – Risk Assessment pathway

HAZARD IDENTIFICATION

EXPOSURE ASSESSMENT

Determine amount of exposure

Material

Environment

Nature and Magnitude of the Risk

SOLUTION 1

SOLUTION 2

THIS MIGHT HAPPEN

THIS MIGHT HAPPEN

THIS MIGHT HAPPEN

THIS MIGHT HAPPEN

Organic Materials
Inorganic Materials

Climate Parameters
Air Pollution
Bio-organism
Introduction

✓ Measurements

1) **Parameters**; Temperature, RH, light, single pollutant concentration levels;

2) **Impact** of the environment on a material (i.e. dosimeter); Dosimeters measure the generic effects of the total (or part of the total) environment on cultural heritage objects of interest, outdoors and indoors.

![Synergistic effects](image)

**Effect**\(_{\text{(NO}_2+\text{O}_3+\text{Climate)}}\) > **Effect**\(_{\text{NO}_2}\) + **Effect**\(_{\text{O}_3}\) + **Effect**\(_{\text{CLIMATE}}\)
Introduction - Objective

 ✓ To evaluate the use of dosimetry (i.e. EWO dosimeter) for Indoor Air Quality assessment in Cultural Heritage Locations

 ✓ Assess the EWO dosimeter results obtained in different types of indoor locations (e.g. Storeroom, historic buildings)

 ✓ Assess the EWO dosimeter results obtained on different geographical locations (e.g. Urban vs Rural)
The EWO – Dosimeter – Working principle

**WHAT**
- Glass substrate
- Spin coated organic polymer (PPO)

**WHY**
- Dust/soiling
- Organic acids
- SO₂
- RH + T
- NOₓ
- Light/UV
- Dust/soiling
- O₃

**HOW**
- Measurement by photo-spectrometer (1)
- Monitoring (3 months)
- Measurement by photo-spectrometer (2)

**The Environmental Effect**
- Acceptability levels (e.g. 1 to 5)

**Light Absorbance**
- 340 nm
- λ (nm)
- Effect
The EWO – Database

Data source:

- EU-projects (MASTER, PROPAINT)
- EEA-Grants projects (NL-Prague)
- Services to CH professionals

GEOGRAPHICAL DISTRIBUTION

- Mexico
- Japan

TYPE OF INDOOR LOCATIONS

- ARCHIVES
- STOREROOMS
- HISTORIC BUILDINGS
- ENCLOSURES
# The EWO – Database

## Geographical Location

<table>
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<tr>
<th># EWO</th>
<th>Location Type</th>
<th>Urban / Rural</th>
<th>Research / Service</th>
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</table>

**Total EWO dosimeter measurements**: 208

**From Research Projects**: 196

**From Services to Cultural Heritage Locations**: 12
EWO - Results

### EWO Response vs. Single Compounds

**EWO-G effect (x1000) = 8.67 + √UV + √T(0.11NO$_2$ + 0.15O$_3$)  \( (R^2 = 0.73) \)**

(NO$_2$, O$_3$) outdoor generated pollutants → infiltrate indoors
**EWO - Results**

**EWO Response vs. Type of Indoor Location**

- **EN:** Enclosures (e.g. showcases, mc-frames); **ST/AR:** Storeroom / Archives;
- **NB:** New buildings; **HB:** Historic buildings;

**EWO Response Variability**

- Ventilation systems
- Air Exchange Rate
- Buildings conditions
- Geographical locations (i.e. Urban, Rural, Traffic)
EWO - Results

EWO Response vs. Type of Indoor Location

EN: Enclosures (e.g. showcases, mc-frames); ST/AR: Storeroom / Archives;
NB: New buildings; HB: Historic buildings;

EWO Response Variability

- Air Exchange Rate (e.g. Enclosures: 0.2 – 15 day⁻¹)
- Volume (e.g. Showcases 0.01 – 70 m³)
- With objects vs Empty
- ...
EWO - Results

EWO Response vs. Type of Indoor Location

EN: Enclosures (e.g. showcases, mc-frames); ST/AR: Storeroom / Archives;
NB: New buildings; HB: Historic buildings;

“Low” EWO Response

- Some of the storerooms and archives were air conditioned with low light levels and low number of visitors
EWO - Results

EWO Response vs. Geographical Location

[Map of Europe with markers for cities like Valencia, London, Mexico City, and Norfolk. The map shows the distribution of EWO response across urban vs. rural areas, with a scatter plot correlating EWO response and NO2 levels.]
IAQ in buildings without climate / pollution control, which in addition are located in highly polluted environments, may constitute a risk for the preservation of cultural heritage assets.
Further Lines of Research

- Combination with other dosimeters (i.e. sensitive to organic compounds)

**PROPAINT** - Improve Protection of Paintings during Exhibition, Storage and Transit (EU Project FP6)

Conclusions

✓ The EWO dosimeter is a useful tool for the assessment of indoor environment with regards to the impact of outdoor generated pollutants acting in synergy with climate parameters on organic materials.

✓ There is a relationship between the type of indoor location and the EWO results.

✓ IAQ in buildings without climate and pollution control, which in addition are located in highly polluted environments, may constitute a risk for the preservation of CH assets.

✓ EWO dosimeter is a useful tool for screening studies in CH locations.

✓ The type of indoor location and its characteristics (i.e. type of ventilation system, air exchange rate, etc) are important factors for the indoor air quality and for possible implementation of mitigation measures.