

# Air Quality Assessment in Cultural Heritage Locations by Dosimetry

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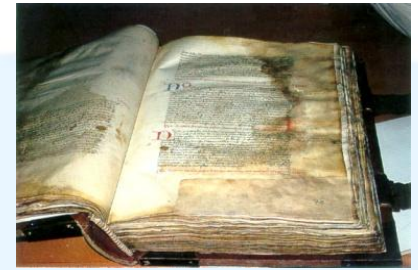
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# Introduction – Air Pollution in CH

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

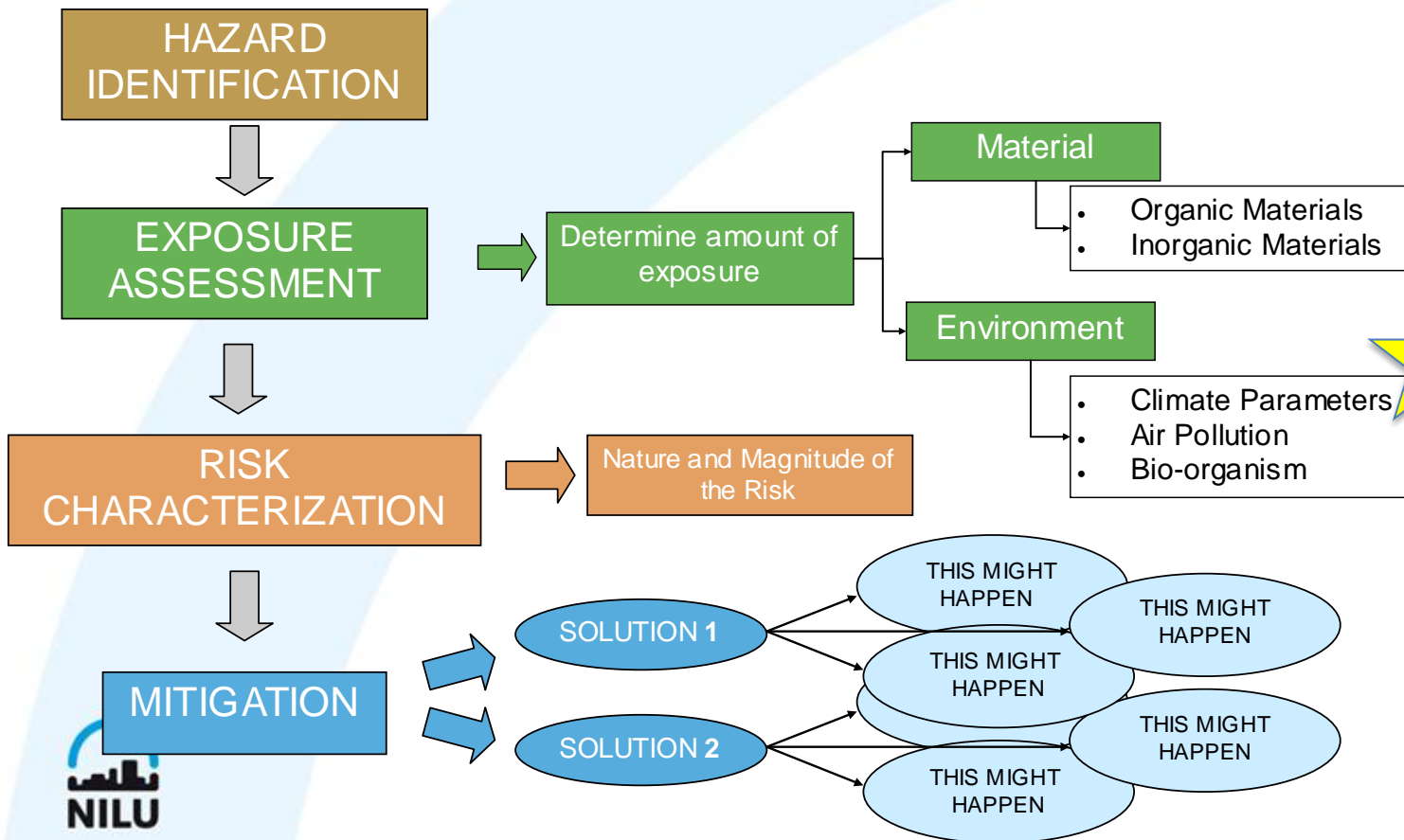


© National Museum in Krakow



© EU Project PROPAINT

## ✓ IAQ Study – Risk Assessment pathway

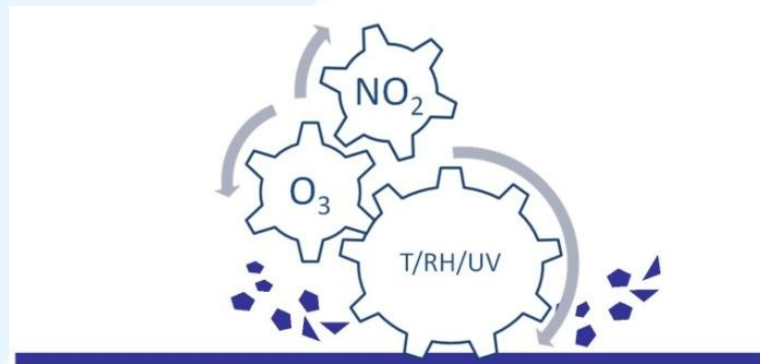


# Introduction

## ✓ 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

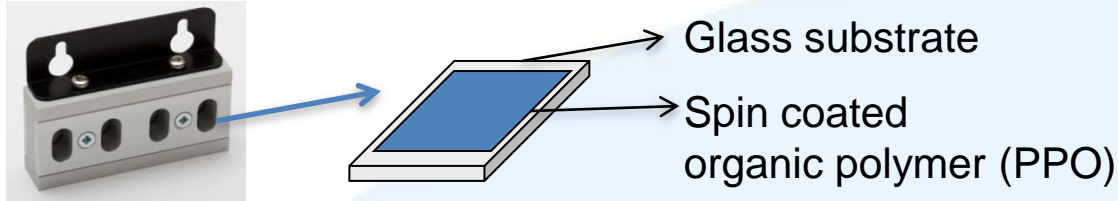
$$\text{Effect}_{(\text{NO}_2+\text{O}_3+\text{Climate})} > \text{Effect}_{\text{NO}_2} + \text{Effect}_{\text{O}_3} + \text{Effect}_{\text{CLIMATE}}$$

## Introduction - Objective

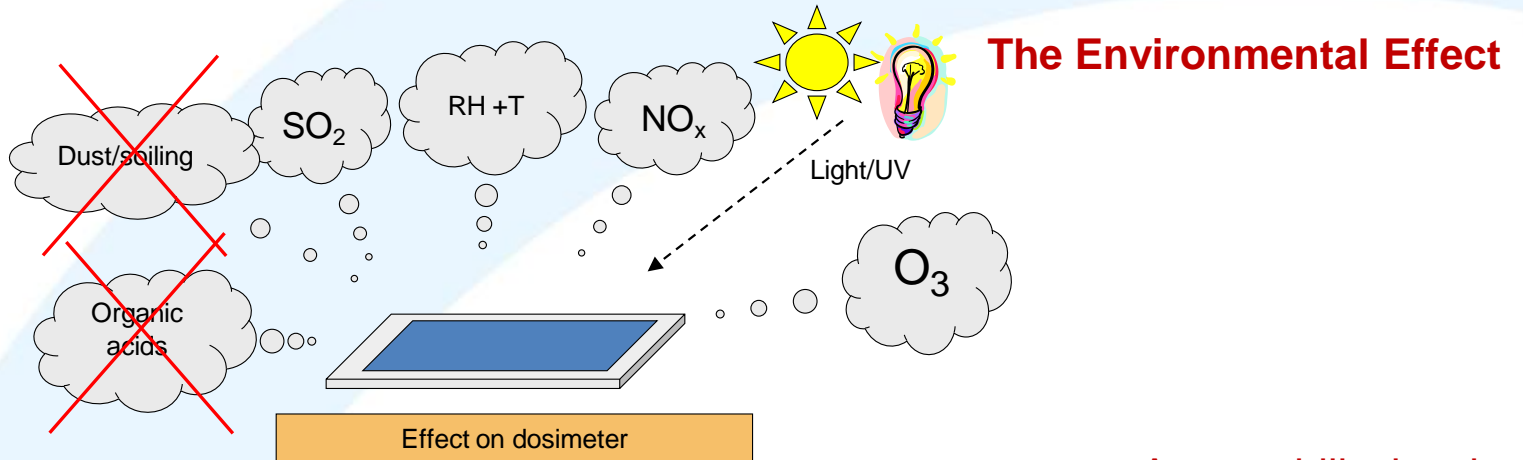
- ✓ To evaluate the use of dosimetry (i.e. EWO dosimeter) for Indoor Air Quality assessment in Cultural Heritage Locations
- ✓ Assess the EWO dosimeter results obtained in different types of indoor locations (e.g. Storeroom, historic buildings)
- ✓ Assess the EWO dosimeter results obtained on different of geographical locations (e.g. Urban vs Rural)

# The EWO – Dosimeter – Working principle

WHAT



WHY

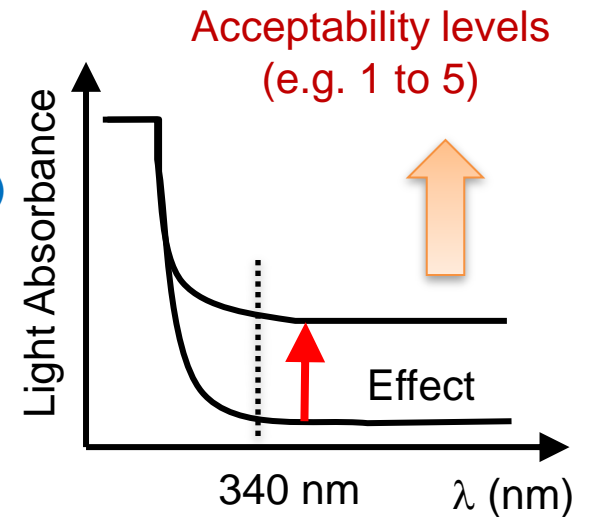


HOW

Measurement by photo-spectrometer (1)

EXPOSURE (3 months)

Measurement by photo-spectrometer (2)





# The EWO – Database

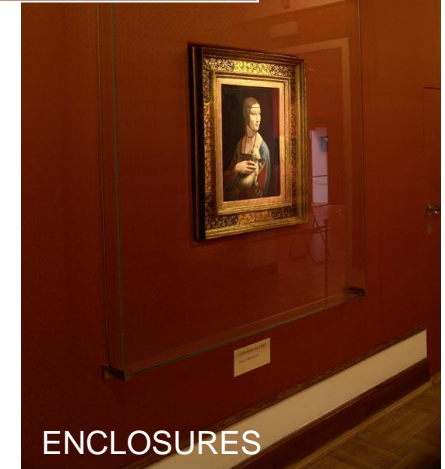
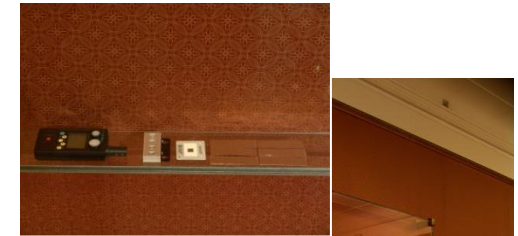
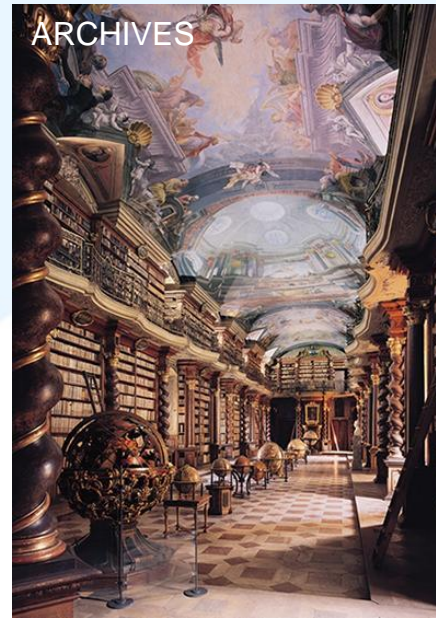
## Data source:

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

## GEOGRAPHICAL DISTRIBUTION



## TYPE OF INDOOR LOCATIONS



# The EWO – Database



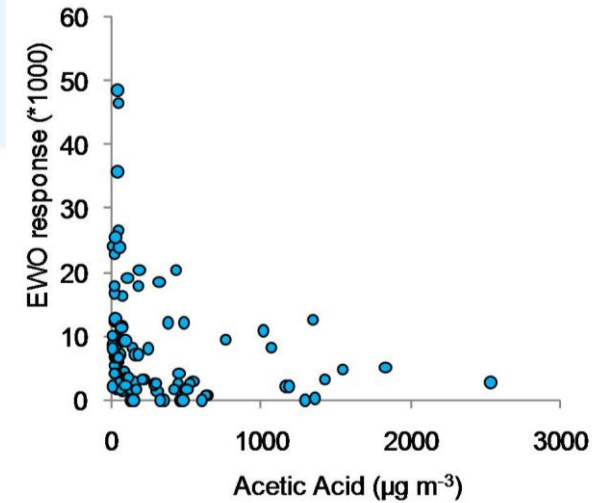
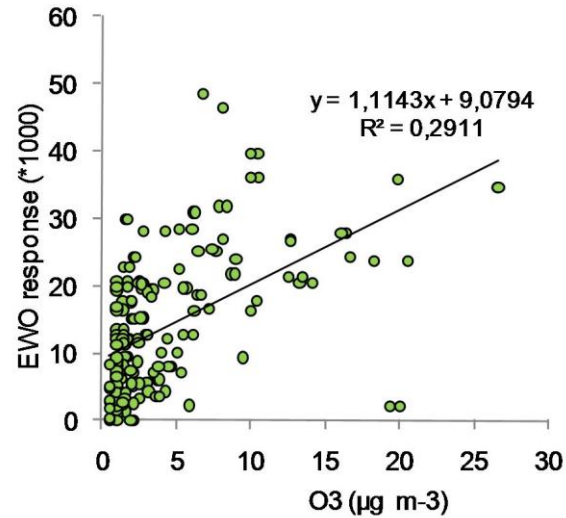
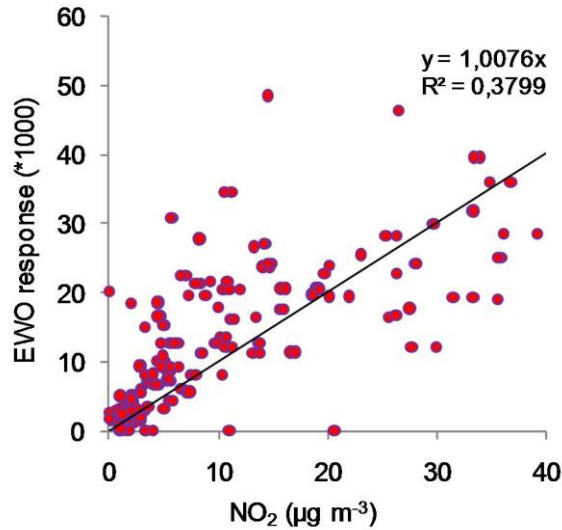
# EWO	Geographical Location	Location type	Urban / Rural	Research / Service
23	Oslo, NO	Historic Building, enclosure	Urban	Both
3	Akershus, NO	New building	Rural	Service
5	Copenhagen, DK	Historic Building, enclosure	Urban	Research
16	Haslach, GE	Historic Building, enclosure	Rural	Research
16	Heraklion, GR	Historic Building, enclosure	Urban	Research
20	Krakow, PO	Historic Building, enclosure	Urban	Research
24	London, UK	Historic Building, enclosure, Storeroom, Archive	Urban	Research
7	Madrid, ES	Workshop, enclosure	Urban	Research
2	Mexico City, MX	Historic Building, enclosure	Urban	Research
16	Norfolk, UK	Historic Building, enclosure	Rural	Research
2	Nurberg, GE	Historic Building, enclosure	Urban	Research
10	Prague, CR	Historic Building, Storeroom, Archive	Urban	Both
16	Rabat, ML	Historic Building, enclosure	Rural	Research
16	Stuttgart, GE	New building, enclosure	Urban	Research
16	Trondheim, NO	Historic Building, enclosure	Urban	Research
2	Valencia, ES	Historic Building, enclosure	Urban	Research
16	Zakopane, PO	Historic Building, enclosure	Rural	Research
1	Tokyo, JP	Storeroom	Urban	Research

<b>Total EWO dosimeter measurements</b>	<b>208</b>
<b>From Research Projects</b>	<b>196</b>
<b>From Services to Cultural Heritage Locations</b>	<b>12</b>



# EWO - Results

## EWO Response vs. Single Compounds



$$\text{EWO-G effect (x1000)} = 8.67 + \sqrt{\text{UV}} + \sqrt{\text{T}}(0.11\text{NO}_2 + 0.15\text{O}_3) \quad (R^2 = 0.73)$$

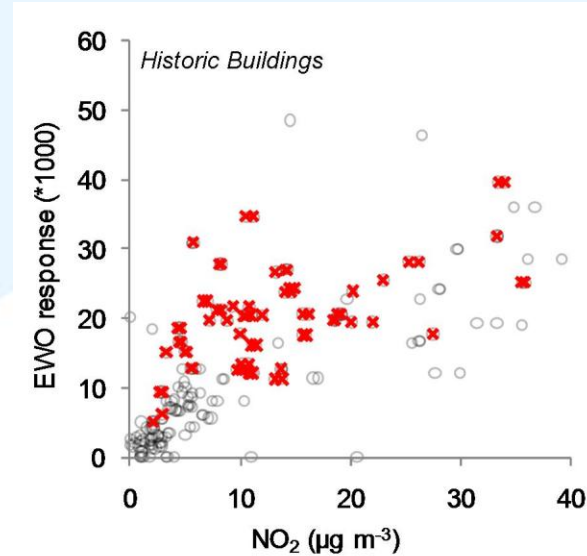
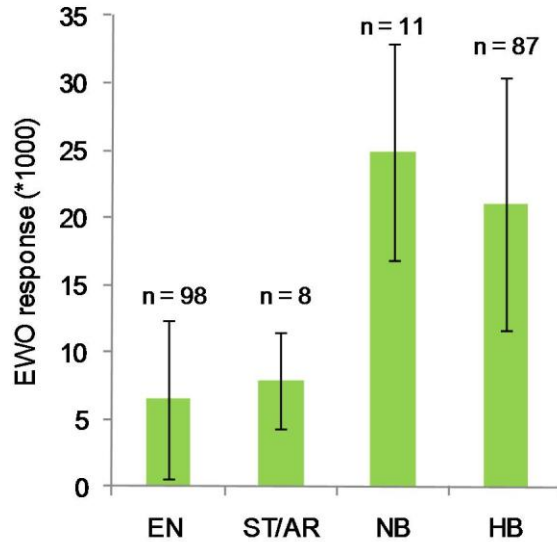
(NO<sub>2</sub>, O<sub>3</sub>) outdoor generated pollutants → infiltrate indoors



# EWO - Results

## EWO Response vs. Type of Indoor Location

HISTORIC BUILDINGS



EN: Enclosures (e.g. showcases, mc-frames); ST/AR: Storeroom / Archives;

NB: New buildings; HB: Historic buildings;

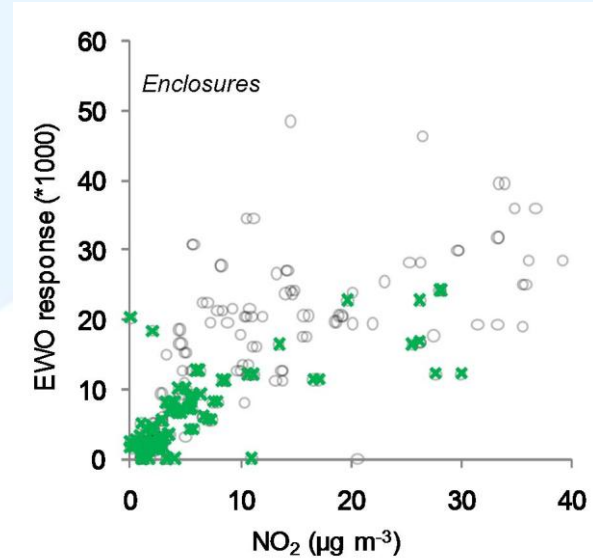
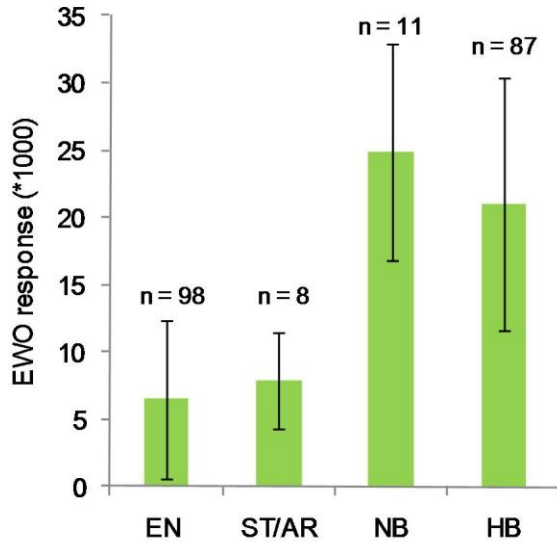
### EWO Response Variability

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

# EWO - Results

## EWO Response vs. Type of Indoor Location

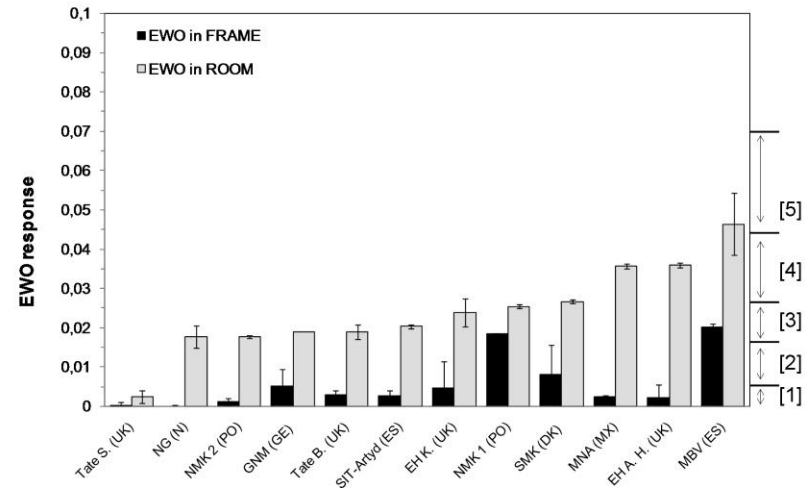
ENCLOSURES



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

### EWO Response Variability

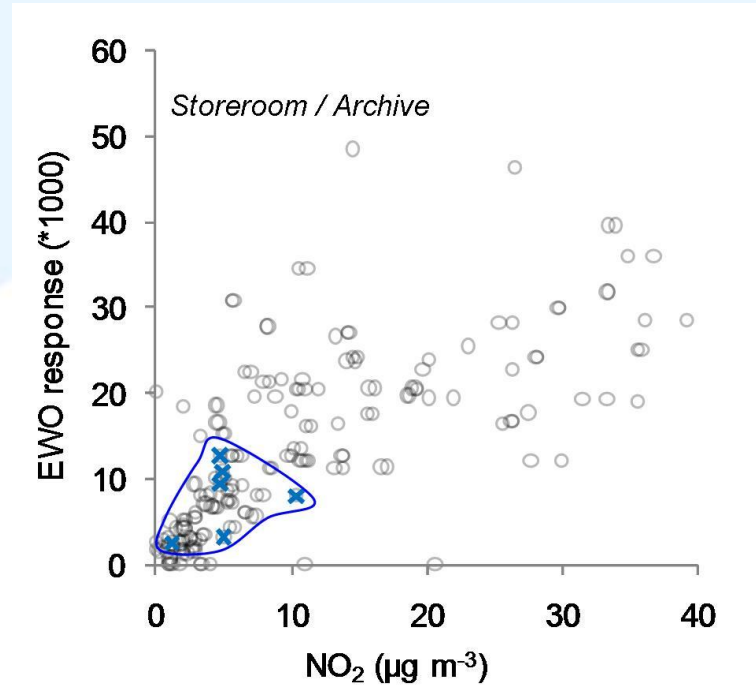
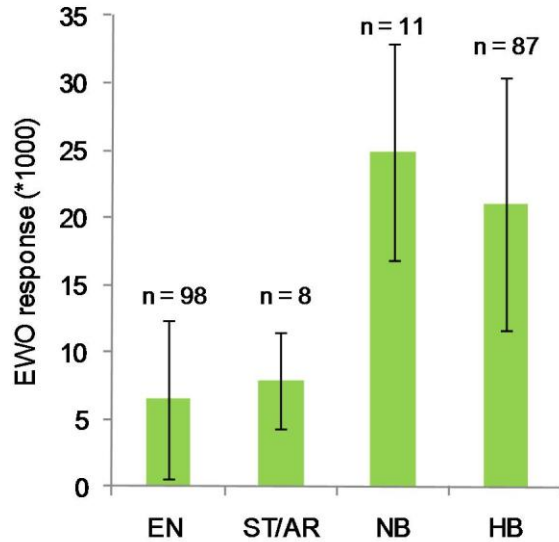
- Air Exchange Rate (e.g. Enclosures: 0.2 – 15 day<sup>-1</sup>)
- Volume (e.g. Showcases 0.01 – 70 m<sup>3</sup>)
- With objects vs Empty
- ...



# EWO - Results

## EWO Response vs. Type of Indoor Location

ARCHIVE / STOREROOM



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

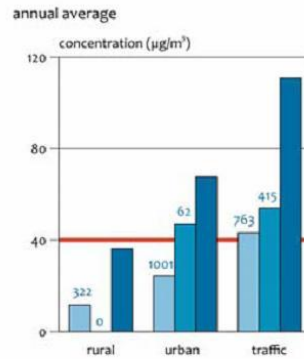
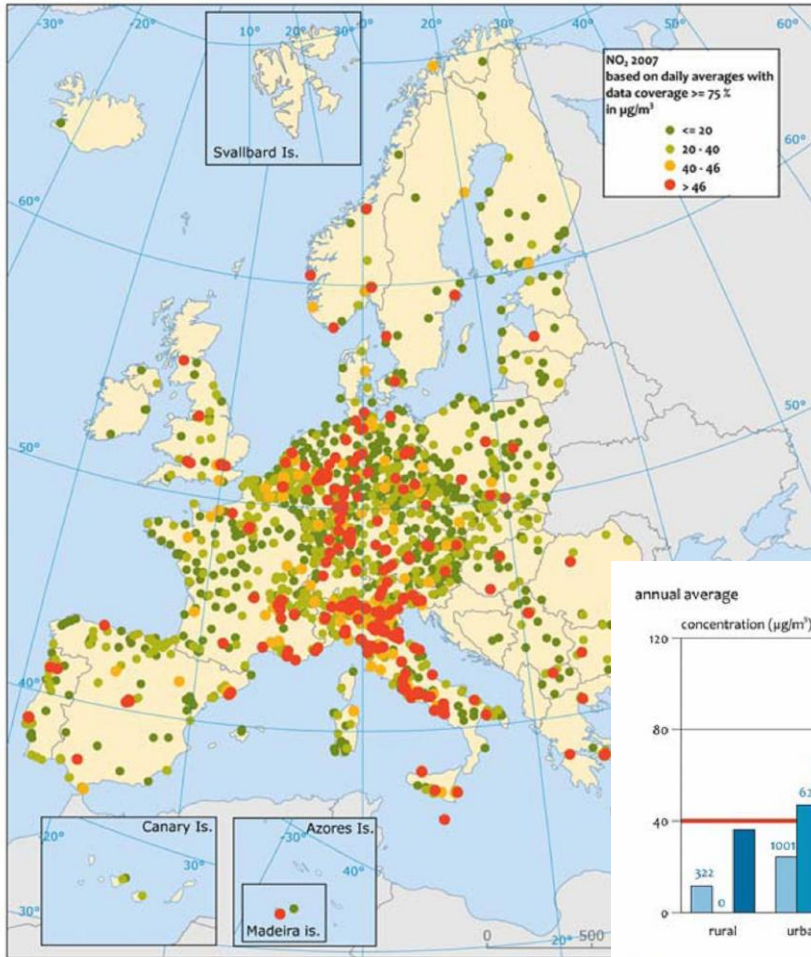
### “Low” EWO Response

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

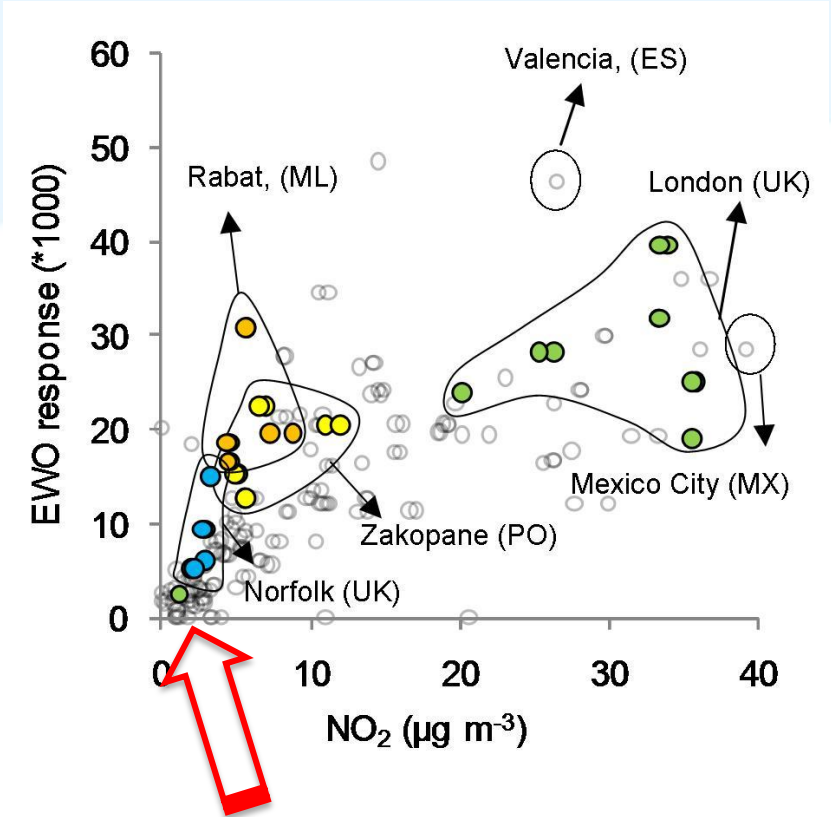
# EWO - Results

## EWO Response vs. Geographical Location

URBAN vs RURAL



■ average  
■ average > limit value  
■ maximum  
— limit value  
 999 number of stations



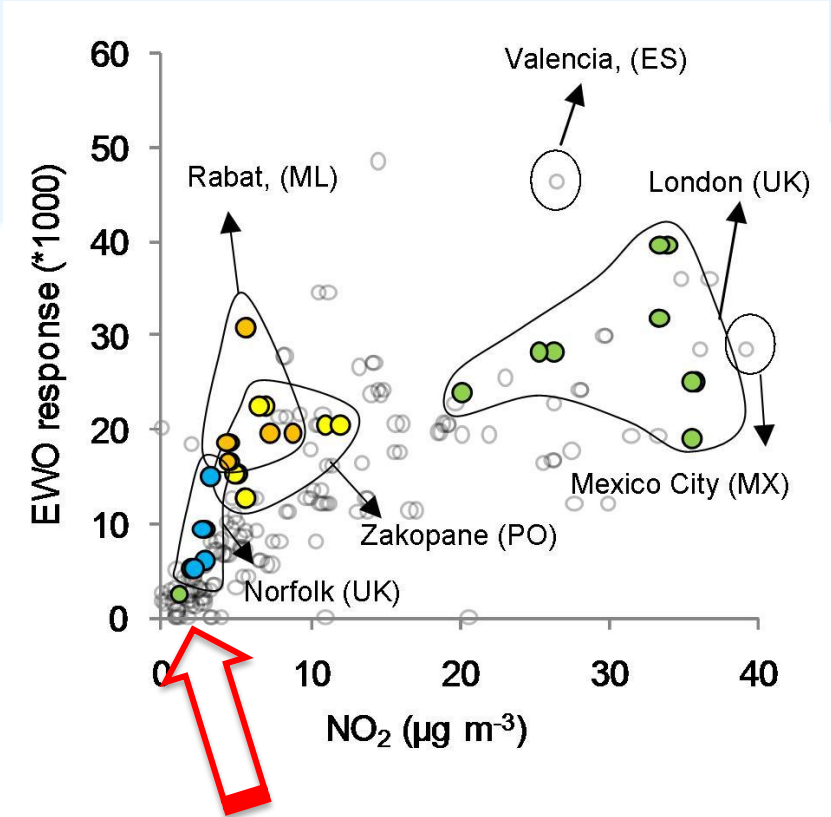


# EWO - Results

## EWO Response vs. Geographical Location

URBAN vs RURAL

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.

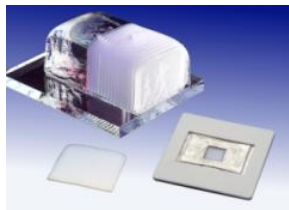


# Further Lines of Research

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

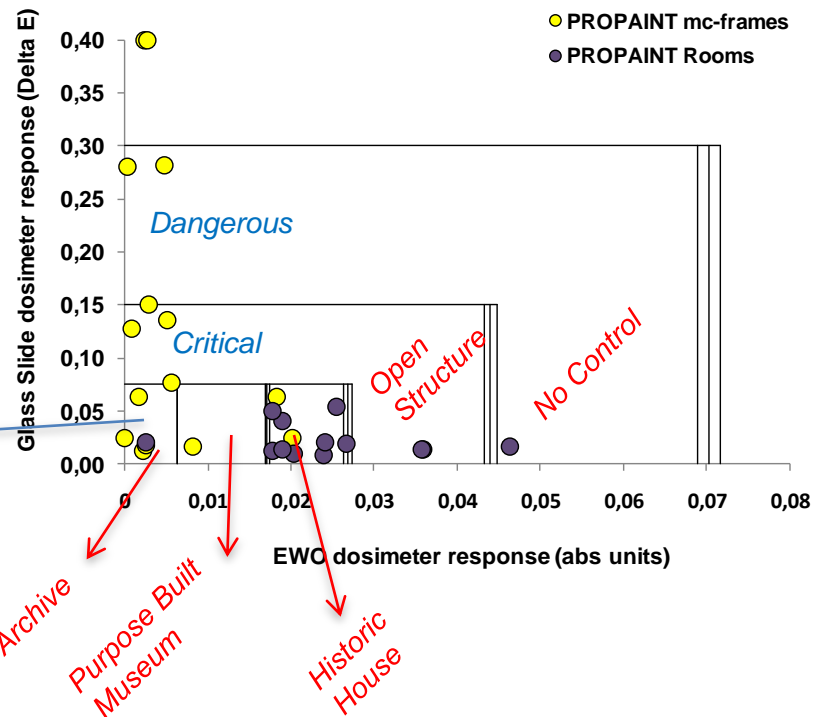


PROPAINT - Improve Protection of Paintings during Exhibition, Storage and Transit (EU Project FP6)



Glass Slide-dosimeter  
(Fraunhofer Institute)

Acceptable



EWO (NILU)

Grøntoft, et al., (2010) *Journal of Cultural Heritage*, (in press)

# Conclusions

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- ✓ The EWO dosimeter is an 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.

