# The relation between use and safeguarding: the case study of the Portico of Glory.

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**Abstract**
Nowadays, when talking about the cultural Heritage, the dilemma "use vs. conservation" includes complex issues, which consider the several interests of the museum sector: as the need to guarantee a healthy indoor microclimate for visitors, but first of all an adequate microclimate for the preventive conservation of the building and the artifacts hosted inside it. Nevertheless, the so-called "optimal" parameters for fulfilling these three needs do not always coincide.
A factor affecting fluctuations in the main microclimate variables - such as relative humidity and air temperature - is the presence of visitors and occupants. Indeed, this contribution shows the correlations between microclimatic variations caused by visitor access and their possible impact on the conservation of the polychrome stones that characterise the Portico of Glory, the narthex of the Cathedral of Santiago de Compostela, Spain.

**Keywords**
Cultural Heritage, Indoor Microclimate, Indoor monitoring, Safeguarding, Fruition, Conservation.

## Introduction

In recent years, in the field of architectural and cultural Heritage, more and more emphasis is being placed on the importance of being able to manage visitors flows in historic buildings. To do it properly, it is necessary to take into account the numerous interests served by the museum sector: if, on the one hand, we want to guarantee the accessibility of the Heritage to as many visitors as possible, both for cultural and economic reasons, on the other hand it is necessary that this access guarantees Heritage's conservation, in a preventive manner, in order to reduce the risks of deterioration of the building itself and of the artifacts guarded inside it. For this reason, it is mandatory to manage: visitor numbers; activation and management of heating systems; etc. The needs are multiple: guaranteeing accessibility; visitor comfort; managing attendance; acting for the preventive conservation of the building and preservation of artifacts.

In preventive conservation of cultural heritage, conservation is understood to mean both the 'host' building and the 'hosted' valuable artifacts; and it can be ensured through the analysis, monitoring and control of the factors affecting the indoor microclimate of the environment we are investigating on.

To define how to balance the needs of visitors, building and artifacts is not obvious at all, because the so-called "optimal" parameters for fulfilling these three needs do not always coincide. Installations, for example, can represent both cause and solution with respect to preventive conservation and accessibility: solution because they can guarantee efficient control of indoor microclimate parameters, cause because in the event of their mismanagement or malfunctioning, there can be a loss of the same control that was hoped for with their introduction, exposing heritage assets to the risk of damage and workers and visitors to thermal discomfort. Another factor

affecting fluctuations in the main microclimate variables - such as relative humidity and air temperature - is the presence of visitors and occupants.

**Goals**

This contribution shows the correlations between microclimatic variations caused by visitor access and their possible impact on the conservation of the polychrome stones that characterise the Portico of Glory: narthex of the Cathedral of Santiago de Compostela, Spain, and masterpiece of late Romanesque European sculpture, realised between 1168 and 1188.

To achieve this goal, investigations were carried out in 2019, to verify:

1. the geometric, material and thermophysical characteristics of the architecture under investigation;
2. the history of the use of the narthex and of any architectural modifications;
3. the characteristics of the indoor microclimate, during the Cathedral's closing and opening hours, thanks to the data of the indoor monitoring campaign carried out between 25 February 2019 and 26 October 2019.

The analysis and interpretation of data obtained from the technologies used for the monitoring campaign makes it possible to assess whether, and in what terms, the historic, artistic, and cultural heritage under study is at risk of damage due to the current management of accesses.

**The case study**

During the P.h.D. research of the author of this paper, from 8th July 2019 until 8th November 2019, it has been possible to collaborate with the Architect Soledad García Morales, Director of the Department of Construction and Architectural Technology at the Polytechnic University of Madrid, who at the time was involved in the restoration of the interior of the Cathedral of Santiago de Compostela and the study of the indoor microclimate of the Portico of Glory, narthex of the Cathedral.

Architect García Morales made available the indoor microclimate monitoring data collected by 11 active probes inside the Portico of Glory from 25th February 2019 until 26th October 2019. This provided 8 months of continuous monitoring, which has been used to proceed with the study of the indoor microclimate of the narthex of the Cathedral of Santiago de Compostela: Portico of Glory. Data were collected directly by the architect Soledad García Morales, who visited the Cathedral monthly during that period, in order to download approximately 4800 data for each probe positioned inside the Portico of Glory and in the rest of the Cathedral.

Specifically, for this study were considered data from one of the above-mentioned probes, which was located approximately in the centre of the Portico. These data made it possible to identify the periods of the year during which the indoor microclimatic conditions are unfavourable for the preventive conservation of the polychrome stone sculptures which constitute the narthex itself.

The MIBAC[2] and UNI 10829[3] standards are suggested for the polychrome stone sculptures conservation are shown in the following table (Table 1.)- the investigations show that a reduction in the number of people per visiting group should be considered. (We specify that in the standards considered above -MIBAC and UNI 10829- no distinction is made by specific type of stones. (We specify that in the standards considered above -MIBAC and UNI 10829- no distinction is made by specific type of stones).

| Material | Range RH (%) | Range T (°C) |
|---|---|---|
| Stone | 45-65 | ≤30 |
| Polychrome sculptures | 45-65 | 19-24 |

Table 1. Heritage preserved within the Portico of Glory

Since July 2019, after almost nine years of restoration of the original polychromes of the Portico of Glory, it has been accessible to the public. Since then, groups of a maximum of 25 people, accompanied by a guide, can access this area from Monday to Sunday, from 9:00 a.m. to 8:00 p.m.; visits of approximately 15 minutes are allowed, followed by a break of another 15 minutes before the next group enters. The access arrangements adopted for the reopening of the Portico of Glory to the public were established before the advent of the global pandemic caused by COVID-19, and are maintained today.

**The visitors' influence**

To verify the influence of visitors and their guides on the indoor microclimate of the Portico of Glory, the Mixing Ratio (MR) was calculated during the Cathedral's closing and opening hours.

The formulas used to calculate MR are as follows[1]:

$$Vps = \frac{e^{(77{,}3435+0{,}0057(273(K)+T(°C))-\frac{7235}{273(K)+T(°C)}}}{(273(K)+T(°C))^{8,2}} \quad (Pa) \quad (1)$$

$$VP = Vps * (RH/100) \quad (hPa) \quad (2)$$

$$MR = B * VP/(P_{tot} - VP) \quad (g/m^3) \quad (3)$$

where:

Vps is the saturated water vapour pressure (Pa);

VP is water vapour pressure (hPa);

MR is the Mixing Ratio;

$P_{tot}$ is the Total Air Pressure (hPa);

RH is the relative humidity (%);

T is the air temperature (°C)

B is 621.9907 (g/kg).

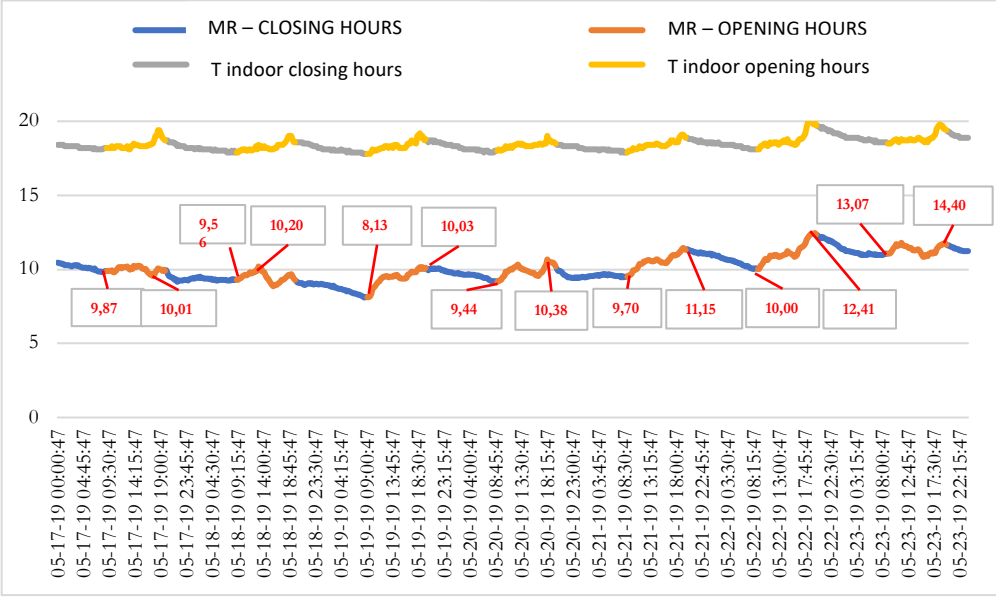
Considering a model week of the winter, spring, summer, and autumn periods as example (Table 2.) from the monitoring data, we see that the average increase in water vapour in the air due to the presence of visitors in the Portico of Glory is 1.271 g/kg.

| Opening hours - Model weeks | Winter (8-14 March) | Spring (17-23 May) | Summer (5-11 July) | Autumn (3-9 October) |
|---|---|---|---|---|
| Mean Mixing Ratio difference | +1.042 g/kg | +1.258 g/kg | +1.204 g/kg | +1.581 g/kg |

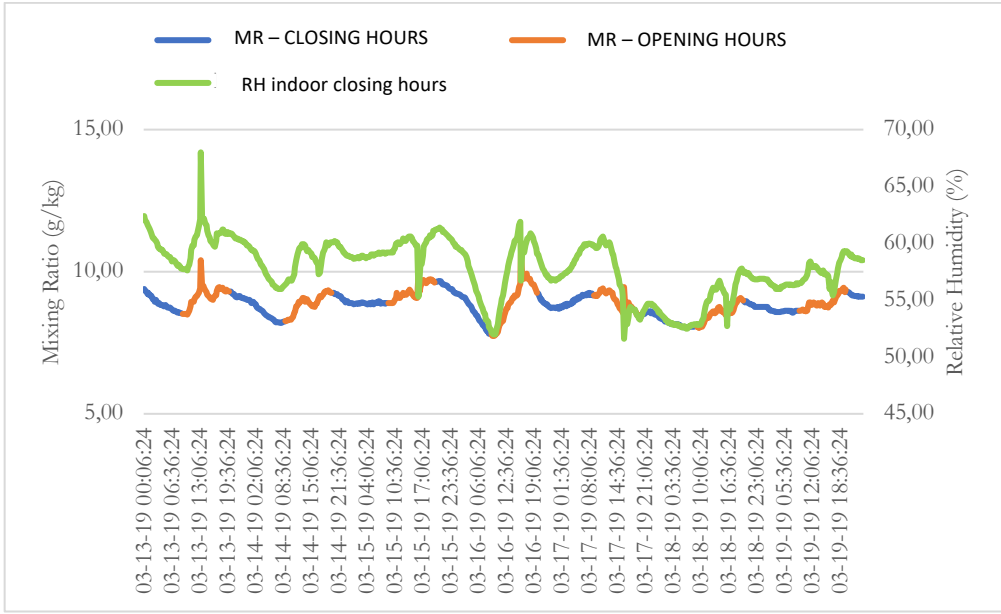
Table 2. Model week: average difference between minimum and maximum MR.

Clearly, the presence of people inside of the Portico of Glory affects both the temperature and relative humidity parameters: as the number of visitors increases, the Mixing Ratio increases, as does the temperature and relative humidity. In order to investigate in detail how attendance affects the microclimate of the narthex, a model week was identified as a representative sample for each season, for which the trends of T, RH and MR were studied, considering when the Cathedral was open and closed to the public.

An example of spring data is given below:




Graphic 1. Model week in spring: 17-23 May 2019




Graphic 2. Model week in spring: 17-23 May 2019

It emerged that each day, during the four seasonal periods analysed, it takes approximately 5 hours - starting from closing time - for the Mixing Ratio to decrease and completely dispose of visitor emissions. For this same reason, the differences between the maximum, minimum and average values calculated for the parameters of T, MR and RH during opening and closing hours are very small. The only parameter for which more consistent variations can be read is relative humidity, which is evidently more sensitive to even small variations: differences between opening and closing hours of between 1% and 2% are recorded (Table 3.). Moreover, data show an almost daily increase in MR around 16:00 in spring; 15:0 in summer and 16:45 in autumn: either because it corresponds to Spanish lunch time or linked to the opening of doors and/or windows. The drop in MR is very sudden, so the second hypothesis is more plausible.

| | T °C | | | MR g/kg | | | UR % | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Min** | **Max** | **Media** | **Min** | **Max** | **Media** | **Min** | **Max** | **Media** |
| Winter | | | | | | | | | |
| Opening | 16 | 19.70 | 16.72 | 7.74 | 10.60 | 8.96 | 51.60 | 68 | 58.06 |
| Closing | 16 | 17.10 | 16.54 | 7.81 | 9.68 | 8.79 | 52.50 | 62.40 | 57.60 |
| Spring | | | | | | | | | |
| Opening | 17.8 | 20 | 18.51 | 8.12 | 12.45 | 10.27 | 48.6 | 66 | 58.57 |
| Closing | 17.8 | 19.7 | 18.38 | 8.10 | 12.31 | 10 | 48.5 | 65.1 | 57.50 |
| Summer | | | | | | | | | |
| Opening | 21 | 23.6 | 22.11 | 12.46 | 15.05 | 13.72 | 58.6 | 65.4 | 62.36 |
| Closing | 21 | 23.3 | 21.96 | 12.48 | 14.78 | 13.19 | 58.1 | 63.2 | 60.55 |
| Autumn | | | | | | | | | |
| Opening | 20.3 | 22.3 | 21.45 | 10.53 | 13.80 | 12.54 | 53.9 | 63.6 | 59.64 |
| Closing | 20.3 | 22.2 | 21.30 | 10.55 | 13.32 | 12.21 | 54 | 61.8 | 58.68 |

Table 3. T, MR, RH: values measured during opening hours (daily from 9 a.m. to 8 p.m.) and closing hours, in the different seasons

**Conclusions**

Considering that the heritage of the Portico of Glory consists mainly of polychrome stones -for which the MIBAC and UNI 10829 standards are shown in Table 1- the investigations show that a reduction in the number of people per visiting group should be considered.

Indeed, the presence of visitors constantly affects the indoor microclimate of the Portico of Glory. But, in which way? Air temperature values, although they increase in the presence of visitors, are always below 25°C and above 15°C (a favourable range in terms of preventive conservation of polychrome stone sculptures); while relative humidity values -a parameter that has already put the Portico of Glory at risk in the past, making its restoration unavoidable- often exceed the 65% threshold (suggested by reference standards) due to the presence of visitors.

Furthermore, with a view to future research in the field of indoor microclimate, it would be essential for these investigations to present a common methodological line, a standardisation of at least the monitoring systems used (both with regard to probes, sensors and the variables considered -such as air temperature, relative humidity, etc.-). The scientific literature of the last ten years, in fact, presents a series of unconnected case studies, in which different methodologies, different monitoring equipment and different virtual modelling and simulation

software are used: research with distinct approaches exists in this field[4]. Finally, such research often does not sufficiently clarify the relationship which exist between microclimate and risk of damage. For this reason, the author of this paper have developed a microclimate risk index (HMR - Heritage Microclimate Risk) and a damage prediction index (PRD - Predicted Risk of Damage)[5]. These indices, which will be applied and refined in future research, are applicable not only to museums, on which most of the research in this field is focused[6], but

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