The Use of the Analogue Method to Identify Peculiar Microclimate Patterns: the Case Study of Mogiła Abbey in Kraków

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Abstract

The microclimate monitoring in the historic churches of Mogiła Abbey (Kraków, Poland) was carried out to study the impact of the environmental variables on the organic and hygroscopic artworks preserved inside. A new index was proposed to evaluate the quality of thermo- hygrometric time series, taking into account the European Standard: EN 15757:2010. Several statistical approaches were applied to understand the variations of thermo- hygrometric parameters and their relationship with CO_2 concentration. Moreover, the Analogue Method for the first time used in the applications of conservation sciences was proposed to analyse peculiar microclimatic cases.

Introduction

Historic churches store valuable artworks (sculptures, frescoes, wooden artworks, etc.), however microclimate conditions are often not beneficial for their conservation. In fact most historic churches are not designed to be heated and for centuries the indoor ambient conditions of these buildings have been mainly regulated by the outdoor climate [1,2]. However human comfort has led to heat the churches.

This paper introduces several strategies to study the impact of environmental parameters on the preservation of organic and hygroscopic cultural heritage, to evaluate the goodness of hygrometric series for the application of European Standard EN 15757:2010 [3] (Microclimatic Quality Index) and to explore the Analogue Method as an operative tool for predicting damaging patterns.

Mogiła Abbey (Latin: Abbatia B.M.V. de Clara Tumba) is the case study of this analysis. It is a Cistercian male monastery in the Nowa Huta District of Kraków (Poland) and is an architectural palimpsest, where several wooden artworks, Renaissance frescoes and wall decorations (19th century) are preserved. This study has aimed at analysing microclimatic conditions of the Blessed Virgin Mary church in which wooden artworks (a crucifix and an altarpiece) are preserved. In this site a heating system (hot air blow, i.e. central heating) is switched on during cold seasons from November to April.

Materials & Methods

The series of temperature (T), relative humidity (RH) and carbon dioxide (CO_2) concentration covering the period from April 2012 till January 2014 were analysed. As for the monitoring system, it was as follows: 3 thermo- hygrometric sensors (S- THB- M002 assembled on Micro Station data logger (H21- 002) distributed by Onset Computer Corporation, USA) of which 1 in the apse and 2 on the cornice at 11 m and 1 CO2 sensor (GMM 222 (F0N0A4A2A1A module) distributed by Vaisala) on the cornice at 11 m. Acquisition and recording time are set to 5 minutes to study the short- term fluctuations due to the heating system of the church and to the large number of visitors. Before applying univariate and multivariate statistics to study daily cycles and seasonal trends, the quality of the time series was investigated. A Microclimatic Quality Index (MQI) was proposed to evaluate the goodness of time series taking into account the European Standard EN 15757:2010. The MQI was defined as a linear combination of the ratio between number of records monitored within a specific

category based on the accuracy of an instrument used for the monitoring and the length of the time series with appropriate coefficients. The Time Weighted Preservation Index (TWPI) is an attempt to link temperature and relative humidity with the rate of chemical deterioration of materials [4]. The results are expressed in years and give an idea on the quality of a place (not air conditioned) in terms of preservation. Finally, the Analogue Method [5] was proposed and explored as an operative tool to predict future environmental conditions (taking into account T, RH and CO_2 series), even when dealing with systems whose equations are not known.

Results

We found high MQI for the all-time series recorded by the thermo-hygrometer sensor. The RH daily span vs T daily span is plotted in Fig. 1. It can be noticed that when the heating system is switched on (red dots) ΔT_{max}=6°C and ΔRH_{max}=30%: the variations are smaller when the system is not active (black dots). TWPI value reveals that environment conservation is poor and there are fast thermo-hygrometric changes. Finally, the analogue method found several analogues (5652) and the cases, where the distance between present and past states is greater than 24 hours, are 12%. From these, over half cases allowed to predict the temporal evolution of present states at one hour step.

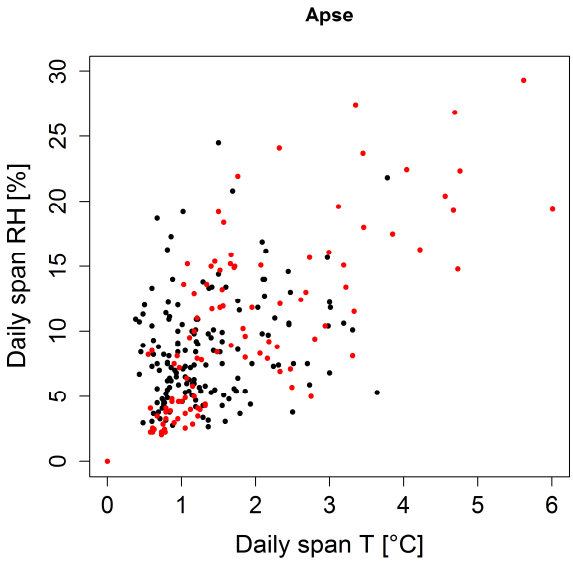

Figure 1, Comparison between the daily span of relative humidity (RH) and temperature (T) during monitored period in the apse. Red dots are thermo- hygrometric daily span when heating system is switched on, while black dots are ones when heating system is switched off.

Conclusions

The Time Weighted Preservation Index indicates that the indoor microclimatic conditions are not suitable for the conservation of organic materials a very strong statement, wood generally is very resistant to chemical degradation which TWPI assesses, maybe remove. It was found that the Analogue Method can be used as a good operative tool to understand and possibly predict the temporal evolution of present state at 1 hour step and to identify cases characterized by high CO_2 concentrations when this parameter is used as discriminant factor.

References

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