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COMPARISON OF INDOOR CLIMATE FEATURES FOLLOWING DIFFERENT CLIMATE GUIDELINES IN CONSERVATION EXAMPLES OF SELECTED CHURCHES IN ALBANIA

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Abstract

Recommendations for relative humidity and temperature in different buildings of cultural heritage were initially developed from practical surveys on the interaction between works of art and the surrounding environment with its climatic features. Nowadays there are different approaches in terms of conservation of cultural heritage, while a specific European standardization activity in this field of conservation is essential to acquire a common unified scientific solution to the problems relevant to the cultural property. The cultural heritage monuments are exposed to weather and influence of various environmental parameters. Physicals, chemicals and biological factors interact with constitutive materials inducing changes both in its compositional and structural characteristics. A certain aspect of matter transformation is due to the metabolic activity connected with the growth of living organisms. A scientific approach is essential for the conservation of cultural heritage as a preliminary basis that will ensure effective planning of ordinary and extraordinary maintenance works, as well to assure their efficacy and durability. The scope of EN 15757:2010 is to establish standards in the field of the processes, practices, methodologies and documentation of conservation of tangible cultural heritage to support its preservation, protection and maintenance and to enhance its significance. In this paper we are focused on standardization on the characterization of deterioration processes and environmental conditions for cultural monuments in Albania (both church and mosque, primarily, but not only), with regard to indoor environmental climate conditions (temperature, relative humidity) very helpful with regards of conservation, restoration, repair and maintenance. Three old churches of St. Marry of Zvernec, St. Mary in Bishqethem Lushnja, dedicated to Christ's ascension, and the St. Nicola Church in Shelcan Elbasan with its spectacular interior completely covered with frescoes by Onufri that belongs to 15th century were considered as case study within current paper.

Keywords*: cultural heritage; indoor climate; conservation; church; EN 15757:2010*

Introduction

This European Standard is a guide specifying temperature and relative humidity levels to limit climate-induced physical damage of hygroscopic, organic materials, kept in long-term storage or exhibition (more than one per year) in indoor environments of museums, galleries, storage areas, archives, libraries, churches and modern or historical buildings [1]. In this paper are presented the standards requirements following EN 15757:2010 for the conservation of the indoor environment of the cultural heritage in Albania. The scope of EN 15757: 2010 is to establish standards in the field of the processes, practices, methodologies and documentation of conservation of tangible cultural heritage to support its preservation, protection and maintenance and to enhance its significance [2]. The conservation and restoration of art works

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in Albania has been considered as an interdisciplinary approach [3, 4]. The particularities of post byzantine churches and other religious monuments as mosques has been highlighted, while the importance of mural frescoes and other artworks is seriously threaten by the influence of environment and biological factors [5]. The scientific research on bio-deterioration of works of art is known for over several decades, while in the last decades the surveys and proposals for adequate conservation techniques of monuments have significantly advanced [5]. It was demonstrated that the preference of microorganism for some category of substrate is related to their susceptibility [6, 3, 4, 7, 8, 9]. During the past decade studies reveal that in post byzantine churches of Albania fungal attacks appear when improper conditions of maintenance, humidity variation exist and other environmental factors for the churches [5, 6]. Similar surveys confirmed the same results [10, 11].

The determination of the temperature and relative humidity ranges, which are optimal for preservation, is not simple due to the variety and complexity of the materials the objects comprise. Temperature has a direct effect on preservation but also an indirect effect as it controls relative humidity of the air. The changes and fluctuations in temperature and relative humidity should be considered from a static point of view of allowable levels or ranges and from a dynamic point of view, i.e. rate of change, duration of cycles and frequency at which cycles are repeated should be taken into account. Deterioration is often of a cumulative nature and may be exacerbated by the number and the intensity of the individual environmental hazards. Changes and fluctuations of temperature and relative humidity cause non-recoverable physical changes in materials although this is not always perceptible to the human eye. Vulnerability to deterioration mechanisms may increase with ageing. The same temperature and relative humidity fluctuations may generate different effects depending on the type of object and its age.

The Post-byzantine churches of Albania are used as a case study with the objective to identify opportunities and challenges with contemporary European standards for cultural heritage [5, 6]. By combing a qualitative study of how indoor climate control is managed with a discussion of the use of existing outcome-oriented EN standards in churches we outline both the organizational and technical contexts in which standards are to be implemented in Albania. We hypothetically apply the recommendations given by EN 15757:2010 in couple of churches located in different climatic zones of Albania starting from Mediterranean lowland (Adriatic coast) and continental one. This exercise is made to identify the strengths and limitations of an advanced positive outcome-oriented approach.

The European standard EN 15757:2010 Specifications for temperature and relative humidity to limit climate-induced mechanical damage in organic hygroscopic materials describes a methodology to establish allowable fluctuations based on the historical climate. It is based on the assumption that objects in the collection have adapted to their environment and that by limiting deviations from the historical climate there will be less risk for further damage [12]. In contrast to many other standards targeting the preservation indoor climate, it is exclusively focusing on mechanical damage in organic hygroscopic materials. The method to establish allowable relative humidity fluctuations in EN 15757:2010 is based on the climate history of a specific building. Rather than specifying a constant target level for the whole year or season, this method is based on a moving seasonal average around which variations should be limited.

Material and Methods

The St. Mary's Monastery, also known as the Monastery of Dormition of Theotokos Mary, is a medieval Byzantine church in Zvërnec Island inside the Narta Lagoon, South-western Albania (40°51'38" N 19°39'45" E) (Fig. 1 and 2).

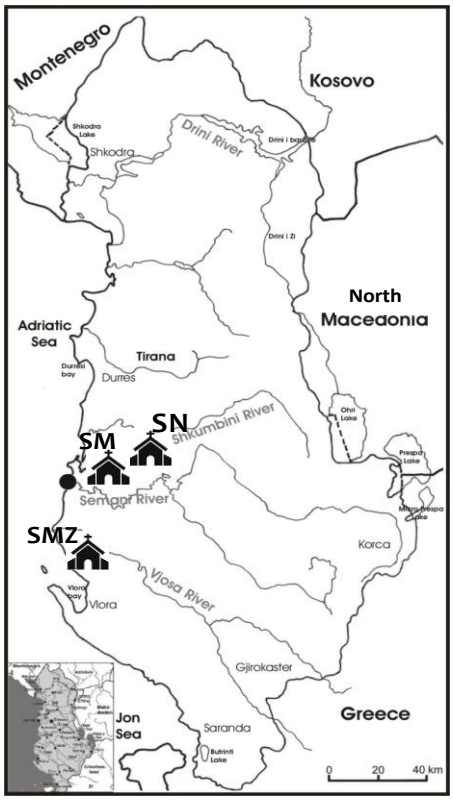


Fig. 1. The location of St. Mary Zvërnec (SMZ), St. Mary Lushnja (SM) and St. Nicola churches (SN)

Fig. 2. The church of St. Mary of Zvërnec and features of climatic effects

The old church of St. Mary in Bishqethem Lushnja, dedicated to Christ's ascension, is one of the important post Byzantine churches, located in village of Bishqethem, of the southwestern part of Myzeqeja, near the city of Lushnja (40°51'38" N 19°39'45" E) (Fig.1).

The St. Nicola Church in Shelcan Elbasan with its spectacular interior completely covered with frescoes by Onufri and belongs to 15th century (41°3'40"N 20°8'3"E). It became a Cultural Monument of Albania in 1948 (Fig.1). The temperature and relative humidity data were colecetd from the archival data of Institute of GeoScience Tirana. Further on experimental tests through temperature and humidity were determined using data loggers from selected walls of both churches. Air temperature and relative humidity were measured every 30 min and processed to obtain average, maximum, and minimum monthly data.

The EL-CC-2 Cold Chain Humidity and Temperature Data Logger were used for measuring and recording temperature and humidity with internal sensors. The device has own capacity of storing 65,200 total readings onto non-volatile internal memory, non-replaceable battery with 12 months typical battery life.

Results and Discussions

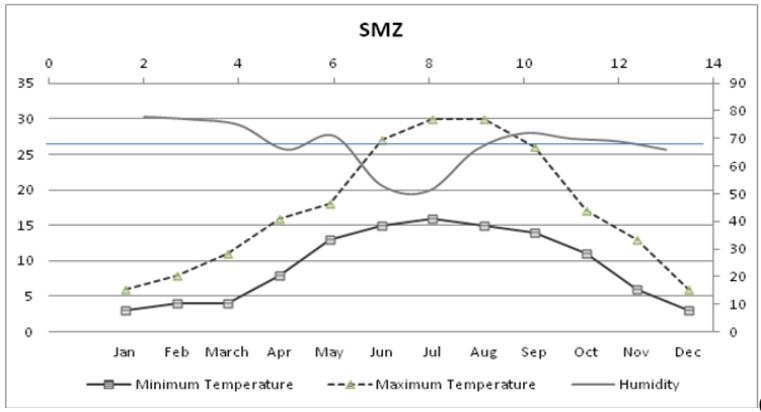
In this work discussed are the factors that directly connect to the degradation of indoor environment of the post-byzantine churches. It is worth taking into account several case studies and experience of the surveys that suggest some basic principles that correlate the degradation with the temperature and humidity parameters: (i) Low air temperatures are not harmful, in themselves, to several cultural heritage monuments objects, while high ones they can be favorable for chemical degenerative processes [13]; (ii) The fluctuation in Temperature of the air film in contact with the object, induces a thermal stress in that, causing expansion, increases damage if the object is made of different materials; (iii) The Relative humidity affects the changes in size and shape of objects and the chemical and biological processes. In particular, all the organic materials capable of absorbing water such as wood, ivory, leather, paper increasing when relative humidity increases and shrink when it decreases, with consequent variations in weight, deformations, breaks fiber, cracks and fissures; (iv) Values of relative humidity greater than 45%, can favor different reactions, including metal's corrosion, dyes' discoloration on cottons, linens, wools, silks and the weakening of organic fibers (textiles and paper), in the presence of light especially; (v) Values of relative humidity above 65%, with temperature values higher than 20 °C, favor the development of molds and accelerate the half-life of many harmful insects [13, 14,5, 6].

Following the data presented in Figure 3 in case of St. Mary's Monastery in Zvernec, the temperature and relative humidity over a year are characterized by moderate to high short term variations and substantial seasonal variations of relative humidity in an interval between 49% and 80 %. The temperature is kept at a minimum of around 4 °C and during summer time it is raised to around 34°C.

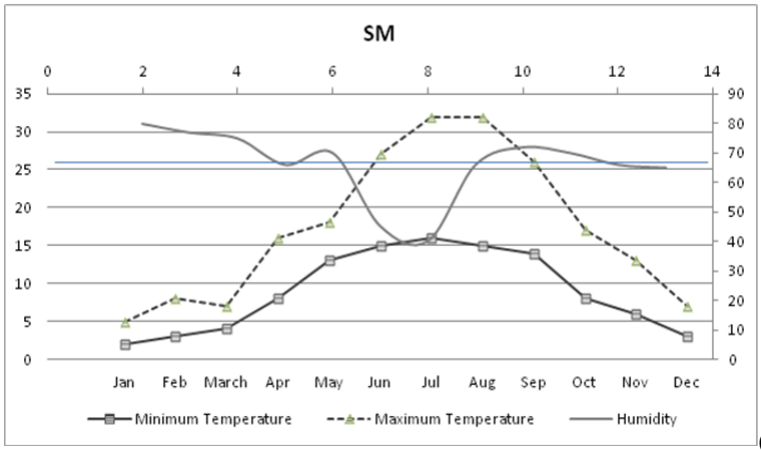
Further on the Figure 3 shows temperature and relative humidity over a year in St. Marry church. It is characterized by moderate to high short term variations and substantial seasonal variations of relative humidity in an interval between 35% and 81 %. The temperature is kept at a minimum of around 3 °C and during summer time it is raised to around 34°C.

The outdoor and indoor climate during winter in combination with comfort requirements makes it unfeasible to comply with the standard recommendation to avoid relative humidity above 75% in order to reduce the risk for biological and mechanical damages. The only viable option for maintaining relative humidity bellow 75% would be to an increase of temperatures. Humidification would cause secondary risks associated with condensation in the building envelope. Therefore the limits of relative humidity in this case would be in between 60 and 45%. These data and recommendations are in line with negative records of church frescoes

degradation [5, 6]. Both phenomena are well correlating among them, while specific construction elements need to be incorporated including insulations and roof recovery.



(a)



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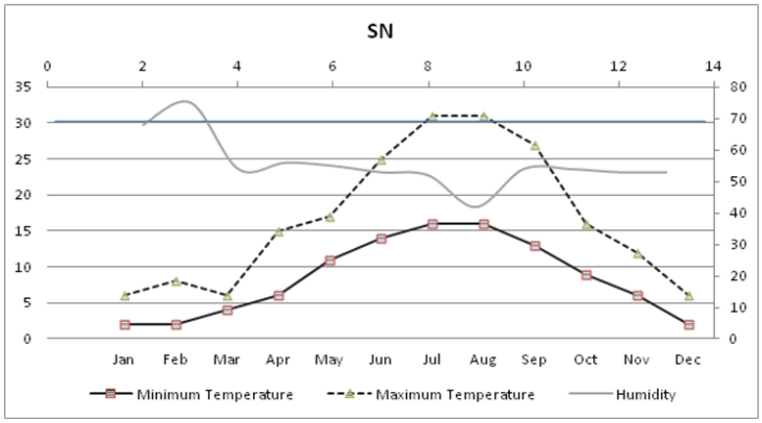

(c)

Fig. 3. Allowable band of RH fluctuations according to EN 15757:2010 in St. Mary Zvërnec (a-SMZ), St. Mary Lushnja (b-SM) and St. Nicola churches (c-SN). RH data from the period 1 January 2017 to 31 December 2017 in St.Mary Zvërnec (SMZ), St. Mary Lushnja (SM) and St. Nicola churches (SN)

In case of St. Nicola church, the oscillations of relative humidity values are in range of 47-75%, while temperatures oscillations are among minimum and maximum values 3 to 13 °C.

The values are in line with EN 15757:2010 requirements and this correlated well with state of frescoes and other construction materials of the church.

The Table 1 shows that climate data values for the St. Mary Lushnja (SM) are in line with Thomson's recommended range as well as that of ASHRAE's guidelines. In fact the data are in line with current state of degradation of this church. The data exceeding limit in terms of RL in case of SMZ is 22%, for SM 33% and SN 3%. The SM shows also the parameter of 'data should stay below 75 % RH' at value of 65%, that means the risk exposure to RH is too high.

Table 1. Indoor climate data from St. Marry Zvernec (SMZ), St. Marry Lushnja (SM) and St. Nicola churches (SN) analyzed by different guidelines taken from references

References	**Description**	**SMZ** Data exceeding the limit	**SM** Data exceeding the limit	**SN** Data exceeding the limit
Thomson [16]	40 to 70% RH	22%	35%	3%
ASHRAE, class of control D [17]	Data should stay below 75% RH	75%	65%	90%
Erhardt et al. [18] ASHRAE class of control B [17]	"Changes caused by environmental fluctuations ±10–15 in the moderate RH region are generally reversible"	Annual mean 71±10% = 81–71% RH: 12.9%	Annual mean 72±10% = 82–62% RH: 13.9%	Annual mean 55±10% = 45–65% RH: 6%
Erhardt et al. [17]	"Changes caused by environmental fluctuations ±10–15 in the moderate RH region are generally eversible"	Annual mean 71±15% = 55–86% RH: 2.8%	Annual mean 72±15% = 57–87% RH: 3.7%	Annual mean 55±15% = 35–70% RH: 2.5%
Mecklenburg [19]	Temperature below 0 resp. 8°C	< 0°C: 0% < 8°C: 22.5 %	< 0°C: 0% < 8°C: 26.2%	< 0°C: 0% < 8°C: 26.2%

Following *Leijonhufvud et al*. 2018, the EN 15757:2010 is focused on relative humidity and T-fluctuations in relation to mechanical damages. The historical climate is used to come up with an allowable band for short term fluctuations which reduces the risk for further damage to hygroscopic materials. In case of Albania, there is a need for more accurate climate data analyses with contexts of long time series. Having in mind the differences in climate conditions in Albania (Mediterranean lowland and continental upland), application of the EN 15757:2010 standard might have own implications. The application of EN 15757:2010 does only require small changes to the indoor climate, but a sophisticated control system is needed, which need further financial means.

The Law on Standardization No. 9870 establishes the rules and procedures for the development of all national standardization activities and the establishment and functioning of the General Directorate of Standardization. General Directorate of Standardization is responsible to develop, adopt, approve, implement, and publish Albanian standards in all fields. It is also responsible to transpose and publish European and international standards.

Conclusions

The particular problem which was considered in this paper is how scientific knowledge and best practices regarding indoor climate control should be shared to local communities and users in order to undertake proper management and conservation of cultural heritage. The use and preservation of the religious monuments and not only, as well as the financial cost and indoor climate particularities are all drivers for halting further degradation of valuable cultural monuments.

A major problem regarding the use of standards in old churches and mosques is the significant diversity between individual churches, sometimes even when they belong to the same period as post-Byzantine one, due to geographic location with Albanian territory.

References

[1] G. Leijonhufvud, T. Broström, *Standardizing the indoor climate in historic buildings: opportunities, challenges and ways forward*, **Journal of Architectural Conservation**, **24**(1), 2018, pp. 3–18.

[2] V. Fassina, *CEN TC 346 Conservation of Cultural Heritage-Update of the Activity After a Height Year Period*. In: G. Lollino, D. Giordan, C. Marunteanu, B. Christaras, I. Yoshinori, C. Margottini (eds) **Engineering Geology for Society and Territory, 8**, 2015, Springer, Cham

[3] A. Meksi, *Criteria for architecture and art monuments restoration,* **Monumentet**, **2**, 1988, pp. 32-35.

[4] R. Gega, A. Meksi, *Travuax de restauration au Monastre D'Aplollonie*, **Munumentet**, **2**, 1989, pp. 12-53.

[5] L. Shumka, *Considering Importance of Light in the Post-Byzantine Church in Central Albania*, **International Journal of Innovative Research in Science, Engineering and Technology**, **2(**11), 2013, pp. 6381-6389.

[6] L. Shumka, S. Shumka, E. Mamoci, *Role of fungi in the deterioration of mural frescoes in the post Byzantine Churches*, **Jokul**, **67(**2), 2017, pp. 35-44.

[7] O. Guillitte, R. Dreesen, *Laboratory chamber studies and petrographical analysis as bioreceptivity assessment tools of buildings materials*, **Science of the Total Environment**, **167**, 1995, pp. 365–374.

[8] B. Cámara, A. De los Ríos, M. García del Cura, V. Galván, C. Ascaso, *Dolostone bioreceptivity to fungal colonization*, **Materiales de Construccion**, **58**(289-290), 2008, pp. 113–124.

[9] D. Maxim, L. Bucsa, M. Moza, O. Chachula, *Preliminary antifungal investigation of ten biocides against moulds from two different church frescoes*, **Annals of the Romanian Society for Cell Biology, 17**(2), 2009, pp. 139-147.

[10] M.I. Moza, M. Mironescu, C. Georgescu, A. Florea, L. Bucșa, *Isolation and characterisation of moulds degrading mural paintings*, **Annals of the Romanian Society for Cell Biology, 17(**1), 2013, pp. 136-142.

[11] R.M. Kabbani, *Conservation collaboration between art and science*, **Chemical Educator Journal**, **2**(1), 1997, pp. 1-17.

[12] * * *, CEN/TC 346 – *Conservation of Cultural Property – Specifications for Temperature and Relative Humidity to Limit Climate-Induced Mechanical Damage in Organic Hygroscopic Materials*, **EN 15757: 2010** (European Committee for Standardization, 2010.

[13] M. Cannistraro, R. Restivo, *Monitoring of indoor microclimatic conditions of an eighteenth-century church, with wireless sensors*, **Advances in Modeling and Analysis B**, **61**(1), 2018, pp. 28-36.

[14] Aghemo, C., Filippi, M., Prato, E. (eds.), **Condizioni ambientali per la conservazione dei beni di interesse storico e artistico. Ricerca bibliografica comparata,** Comitato Giorgio Rota, Torino, 1996.

G. Piccablotto, C. Aghemo, A.Pellegrino, P. Iacomussi, M. Radis, *Study on Conservation Aspects Using LED Technology for Museum Lighting*, **Energy Procedia, 78**, 2015, pp. 1347-1352.

[15] A. Miller, A. Dionisio, M.F. Macedo, *Primary bioreceptivity: A comparative study of different Portuguese lithotypes*, **International Biodeterioration & Biodegradation**, **57**(2), 2006, pp. 136–142.

[16] G. Thomson, **The Museum Environment**, 2nd ed, Butterworths, London, 1986.
[17] * * *, *Museums, libraries and archives*, **ASHRAE Handbook: Heating, Ventilating, and Air-conditioning Applications** (American Society of Heating, Refrigerating and Air-conditioning Engineers), SI ed., AHSRAE, Atlanta, Georgia, 2007, 21.1–21.23.
[18] D. Erhardt, M.F. Mecklenburg, C.S. Tumosa, M.H. McCormick-Goodhart, *The determination of appropriate museum environments*, **The Interface Between Science and Conservation,** British Museum Occasional Paper 116, Ed. S. Bradley, British Museum, London, 1997, pp. 153–163.
[19] M. Mecklenburg, *Determining the acceptable ranges of relative humidity and temperature in museums and galleries - Part 2*, **Structural Response to Temperature.** http://www.si.edu/mci/downloads/reports/Mecklenburg-Part2-Temp.pdf

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