Indoor air quality of museums and conservation of textiles art works. Case study: Salacea Museum House, Romania

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REZUMAT – ABSTRACT

Calitatea aerului din interiorul muzeelor și conservarea operelor de artă din materiale textile. Studiu de caz: Casa-muzeu Sălacea, România

Prezenta lucrare analizează calitatea aerului (temperatură, umiditate, lumină, contaminare cu fungi) în interiorul Casei-muzeu din Sălacea, județul Bihor, și influența acestor factori asupra materialelor textile expuse în interior, în contextul necesității de a proteja elementele patrimoniului și de a diminua riscurile legate de sănătatea umană: locuitorii, turiștii, muzeografii și toți cei care au acces în interior. Monitorizarea temperaturii și a umidității a fost efectuată in perioada 03.06.2018 și 02.07.2018 și a fost utilizat termo-higrometrul KlimaLogg Pro (șapte senzori) cu funcția data logger, iar pentru ceilalți parametri analizați: loggerul de date Luxmeter Extech SDL400 și contorul de oxigen Extech SDL150. Contaminarea fungică a fost determinată folosind metoda de sedimentare Koch. Din cauza temperaturii scăzute și a umidității ridicate a aerului din mediul înconjurător, are loc dezvoltarea microorganismelor și a mucegaiului, iar temperaturile înalte pot duce la deshidratarea fibrelor, prin diminuarea rezistenței și scăderea elasticității acestora; de aceea este necesar să se mențină microclimatul standard al temperaturii și umidității în interiorul casei-muzeu.

Cuvinte-cheie: textil, patrimoniu cultural, casă-muzeu, microclimat, fungi, România

Indoor air quality of museums and conservation of textiles art works. Case study: Salacea Museum House, Romania

The present paper is analyzing the quality of the air (temperature, humidity, light, contamination with fungi) inside the Museum House from Salacea, Bihor county, and the influence of such factors on textile materials that are exposed inside it in the context of the need to protect the heritage elements and in order to diminish the risks related to human health: the inhabitants, the tourists, museographers and all those who have access to the interior. Monitoring of the temperature and humidity was carried out between 03.06.2018 and 02.07.2018 and we used the thermo-hygrometer with data function logger KlimaLogg Pro (seven sensors), and for other analyzed parameters: Luxmeter data logger Extech SDL400 Oxygen meter Extech SDL150. The fungal contamination was determined using Koch sedimentation method. Due to the fact that the low temperature together with the high air humidity of the ambient environment stimulates the formation of microorganisms and mold and high temperatures can dehydrate the fibers by diminishing their strength and decreasing their elasticity, therefore it is necessary to maintain the standard micro climate of temperature and humidity inside the museum house.

Keywords: textile, cultural heritage, museum house, microclimate, fungi, Romania

INTRODUCTION

Understood as a connection between the past and the future, cultural heritage is unique, vulnerable and irreplaceable, so its preservation connects with the legacy that each generation receives and transmits to the next.

Conserving and preserving cultural heritage is an interdisciplinary field that requires, on one side, a close collaboration between restorers, archaeologists, art historians, museum curators and conservators on the other side. This fact represents an important issue and many scientific works were prepared in this field of research [1–3].

A big responsibility in order to conserve, research, and exhibit cultural heritage lies with the museums.

Therefore, the goal of the present paper is to highlight the role of museums in conservation of the textile artwork, so we will further focus on the factors causing deterioration of the textiles inside museums. Most of museum textiles are made of organic fibers, so they are exposed to different factors of degradation: human intervention/incompetence (such as

mishandling, improper storage and displaying, neglect) and environmental factors (light, temperature, humidity, pests, pollutants), and thus their vulnerability is huge.
There are some agents of deterioration that affect the museum textiles [4]:
a) Organic (pests and mold)
There are various rodents and insects (moths, silverfish, firebrats, carpet beetles) which can damage the fibers. The mold is another significant threat to museum textiles, being well known that there is no real cure once this is located in a fabric. Also, the dust can contain soil particles, fragment of human/animal skin and hair, soot and ash, spores, pollen which, in time, gets embedded between fibers and, in majority of cases, it is impossible to remove.
b) Physical
Light exposure (being natural or ultra violet light), high/ low humidity and heat progressively damage the textiles. Not only the colors change, but also the fibers lose their flexibility, becoming weak and fragile.
c) Chemical
The airborne pollution represents a high risk for textiles. Exposed to some noxious gases (Sulphur dioxide, nitrogen dioxide), to acidic or oxidizing substances the fibers can be damaged beyond repair.
d) Mechanical factors can refer to unappropriated procedures of storing and packing (e.g. textiles can be torn because they are stored folded, hung heavy embroidered dresses will eventually break on the shoulder area).
Therefore, conservation is not only the prime function of a museum, but a great challenge.
Among the researches concerning monitoring, controlling and prevention of the fungal deterioration of textile artifacts in the museum we mention those of Lazaridis et al., 2015 [3] and Kareem-Bbdel, 2010 [10] for Jordanian heritage and from Egypt; Spiros Zervosa et al., 2013 [11], about experimental design for the investigation of the environmental factors' effects on organic materials. Cavicchioli et al., 2014 [12] does a research on the particulate matter in the indoor environment of museum in the mega city of Sao Paolo; Kavkler et al., 2015 [13], about contamination of textile objects preserved in Slovene museums and religious institutions. Lech et al., 2015 [14], analyses microflora present on historical textiles with the use of molecular techniques. Di Carlo et al., 2016 [15], wrote about fungi and bacteria in indoor cultural heritage environments: microbial-related risks for artworks and human health.

CASE STUDY

The case study was carried out in the Museum House (figure 1) in Sălacea, Bihor county. It is located in the southern central part of the Sălacea village (according to http://www.cimec.ro/) and represents a servant peasant household from the second half of the 19th century; The material of the house is a beaten-cob construction and the roof is made of reed. The partition of the house includes a small room without natural lighting and a living room with 2 small windows (about 13 m^2). Inside the museum, the owner, Kéri Gáspár, exhibited ethnographic objects, such as furniture, traditional fabrics and other household items, various tools (figure 2). The purpose of this paper was to analyze and correlate the quality of the air (temperature, humidity, fungi content) inside the museum house and the influence of these factors on the objects exhibited inside the museum house, in the context of the need to protect the heritage elements and to reduce the risks related to human health: visitors, museographers, etc.
Our country is located in a geographical area with a temperate climate. Due to the existing topography, the tradition of growing plants containing bast fibers (flax, hemp, jute) and of growing sheep (for getting wool) over the years was transmitted from generation to generation. These are the reasons why in the past the Romanian folk costumes and the articles for decorating the peasant dwellings were made in their own households. So the textiles exhibited in the Museum House in Sălacea are majorly woven textiles such as Romanian traditional clothing, tapestries, textile furnishings, upholstery. The main group of material compositions consist of natural fibers such as hemp, flax, jute and wool.
The first step in conserving and preserving cultural and historic objects is to control the environmental conditions in which they are stored and exhibited. Our task was to find the external factors that have a corrosive effect on the textiles museum's collections. The microclimate factors that influence the physical-mechanical characteristics of textile fibers are mainly

a b

Fig. 1. Exterior (a) and interior (b) Museum House Sălacea (19th century), Bihor county

Fig. 2. The ethnographic collection inside the museum house:
a – Jute (the strap of the Romanian traditional bag); *b* – Wool; *c* – Flax; *d* – Hemp

temperature, relative humidity and sunlight. These are destructive factors of textile fibers, especially natural textile fibers. These natural fibers found in the composition of the materials exhibited in the museum house (figure 2) have appropriate hygienic-functional properties under standard microclimate conditions (air temperature 20 °C ± 2 °C and relative air humidity 65% ± 5%), the variation of these factors lead to the degradation of products made of natural fibers over time.

The microclimate inside the museum house was monitored during 03.06.2018 – 02.07.2018. The following equipment was used: thermo-hygrometer with data function logger Klimalogg Pro (seven sensors), Oxigenometer Extech SDL150; Luxmeter data logger Extech SDL400; Piranometer digital Voltcraft PL-110SM [5–9]. For isolation of fungi air sampling techniques were used. The fungal contamination was determined using the conventional techniques of open plates called Koch sedimentation method [6–9, 16, 17].

As a result of the air temperature and humidity analysis (figure 3) it was found that the average air temperature was 23.3 °C and the average relative humidity was 65%. The temperature should not exceed 22 °C (HG no. 1546/2003), always following its correlation with relative humidity (U.R.), and U.R. should generally be between 50% and 65%.

Concerning the fungal structures identified, the average values of fungi colonies inside the house museum there are 73 in the middle of the museum house, 63 in the corner and 39 in the ceiling level. Geotrichum can give risk factor related to immunosuppression, especially in haematological malignancies (e.g. acute leukaemia, associated with profound and prolonged neutropenia) [18]. Exposures to fungi

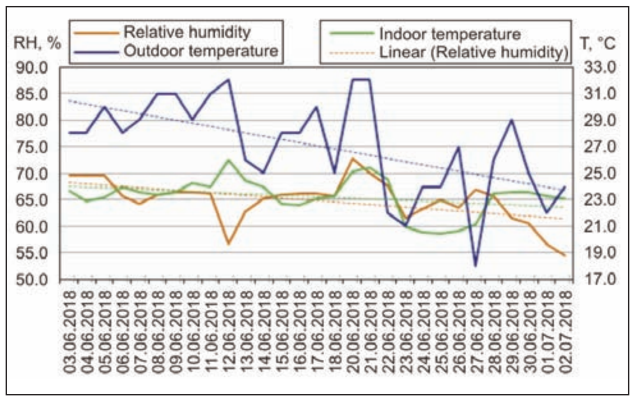

Fig. 3. Variation of air temperature and relative humidity inside and outside of Sălacea Museum House, during the period 03.06.2018 – 02.07.2018

and spores may cause allergic reactions such as sneezing, rhinorrhoea, coughing, eye irritation, skin rash. Fungi such as Cladosporium due to increased allergenic potential may represent a threat to human health if it is present in an increased concentration in closed environments without ventilation [19]. Rarely it is pathogenic to humans, but there have been reported infections of the skin, nails, sinuses and lungs [20–21]. From ascomycete fungi we found Alternaria [15], known as major aeroallergens, representing a major risk factor for the development, worsening and persistence of asthma and allergic rhinitis. Growing indoors can cause hypersensitivity reactions and fever or sometimes it can constitute a potential risk for asthma.

The following figure shows the position of sensors in order to monitor the microclimate and the locations of the fungi colonies inside the museum house.

The intensity measured indoors: 10 to 20 lux (and outside 85,000 lux).

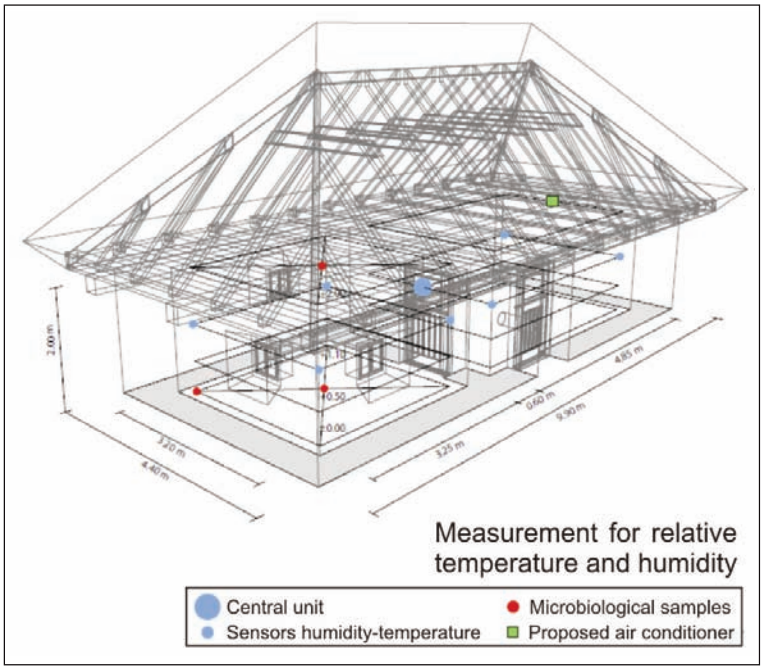

Fig. 4. 3D sketch microclimate monitoring sensors location and microbiological samples

Most of the products exhibited in the museum are flax, hemp and jute and are part of the Liberian fiber category. These fibers have similar properties with small specific differences due to their morphological structure and cellulosic chemical composition. Liberian fibers (flax, hemp, jute) are processed in the form of beads called technical fibers. These are made up of several cells joined together by means of medium-sized blades containing hemicellulose, lignin, etc. These fibers consist of several concentric layers of cellulose, arranged in three distinct areas. The specific morphological structure and chemical composites (cellulose) determine their properties [22–23].

Further on we will show how these fibers are influenced by the microclimatic factors inside the museum house.

Flax fibers can absorb moisture up to 30% of their own mass, hemp between 25% – 30% and jute up to 33%. Oxidative substances, including sunlight, have destructive effects on flax, hemp and jute fibers, resulting in yellowing the materials and reducing their strength over time. Flax is resistant to the attack of microorganisms, it dries quickly and is less affected by the action of light. It absorbs and gives off moisture easily, is a good heat conductor. Unlike flax, hemp textiles are not heat resistant because the fibers are breaking due to high temperature. Under the influence of air and light, the color of the jute turns dark brown. This fiber is less resistant than flax and hemp. Light, air and, above all, humidity make it breakable and reduce its resistance.

Another product exhibited in the museum house is made of harsh wool from Turcana sheep, a type of sheep specific to this area. Turcana sheep wool is a harsh type of wool from a morphologic point of view, of inferior quality, which has barely noticeable curls. The wool is a morphologically pluricelullar fiber, the fiber having 3 layers presenting a medullary canal, the scales of the fiber's structure are thick just like the roof tiles on top of a house. Due to the fact that the medullary layer is developed in the case of Turcana sheep wool, it has a reduced mechanical and chemical resistance as well as a low affinity for dyes. The specific behavior of Turcana sheep wool products is determined by this morphological structure and by the chemical (protein) composition [22–23].

Wool fibers are considered the most resistant to the action of light and atmospheric agents. This is considered the most hygroscopic natural textile fiber. Under normal conditions, wool absorbs from the air 15–18% water. In a humid atmosphere (ie relative air humidity higher than 70%) it can absorb up to 40% water. The water exchange is replenished faster than to fine wool. In wet condition, the strength of the wool decreases by approximately 10%. This decrease is due to the fact that water penetrates the macromolecules of keratin, weakening the forces of mutual attraction. As the temperature rises, the wool becomes fragile, its rigidity increases and the fibres become yellow. In conditions of increased humidity, the wool is attacked by microorganisms (fungi and bacteria) leading to fiber degradation. A much greater danger for wool is moths, heat is a determining factor in their development.

Because the majority of textile objects exhibited inside the museum house are made of natural fibres (flax, hemp, jute, wool) they are a target of microbial attack and degradation, resulting in the loss of structural strength, discoloration and the appearance of some stains. Uncontrollable microclimatic conditions can lead to contamination with fungi of the natural fiber due to their hygroscopic difference. Textile objects that are contaminated with fungi will produce undesirable effects on air quality that will negatively affect human health as they can generate or lead to accentuation of some respiratory diseases, allergic rhinitis, etc.

CONCLUSIONS

As a result of the results obtained during the analysis (average air temperature 23.3 °C; the mean value of relative humidity 65%, it was found that inside the museum house the two fundamental conditions necessary to ensure the optimal conditions of the microclimate are not fully met (air temperature 20 °C ± 2 °C and relative air humidity 65% ± 5%) in order to maintain the physico-mechanical and aesthetic properties of textile materials.

Low temperature together with the high air humidity of the ambient environment stimulate the formation of microorganisms and mold and high temperatures can dehydrate the fibers by diminishing their strength and decreasing their elasticity, so that it is necessary to maintain the standard microclimate of temperature and humidity. Poor air quality caused by pollution leads to dust and dirt. The light can cause the greatest damage, gradually causing colors to fade and turning uncolored textiles to yellow. These external changes are accompanied by a degradation of the fiber. To reduce the growth of fungi in the room, the installation of an air conditioner (figure 4) is recommended in order to ventilate the chambers twice a day for 30 minutes and to provide good ventilation because high humidity stimulates fungal growth.

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