Applying SOBANE Strategy for Risk Management in Museums

Izabela Luiza POP

Technical University of Cluj-Napoca, North University Center of Baia Mare, Romania
pop.izabela.luiza@gmail.com

Abstract

One of the main responsibilities of museums is to keep the cultural heritage safe, so as it can be transmitted to future generations in good conditions. For fulfilling this responsibility, museum specialists have to pay a great attention to identifying, monitoring and keeping under control all the risk factors that can produce damages to museum collections. Therefore, the aim of this paper is to present several tools and instruments that can be used by museums for managing risks. The case study conducted at a Romanian art museum revealed how data loggers, statistical analysis and diagnostic analysis helped the museum to improve its conservation activities. Since incorrect temperature and relative humidity were among the factors with the highest risk of generating damages, a special attention was paid to presenting the statistical analysis of microclimate fluctuations. This analysis played a key role in the process of identifying the causes of fluctuations and finding solutions for improvement. The results of the study develop the literature in the field of museum risk management and provide significant information for those museums interested in improving their conservation activities.

Keywords: management, risks, conservation, museums

Introduction

The purpose of risk management in museology is to protect the museum's collections and assets. Risk management involves identifying all the potential risks, analyzing their causes, measuring the probability of their occurrence and evaluating the consequences or negative impact they may produce (Tomaštík et al., 2020). Also, an important task of risk management is to propose and apply a set of procedures, measures and tools for monitoring and controlling risks in order to eliminate or minimize their effects (Ekwere, 2016).

Risks can be defined as a series of events or factors that may have a negative impact on a museum's "ability to fulfill its mission" (Lindhout, 2019). Museum collections can be affected by many risk factors, such as: incorrect handling and storage (physical damages caused by people), incorrect relative humidity, incorrect temperature, pollutants, pests, light, ultraviolet and infrared radiation, thieves and vandals, emergencies (fires, floods, earthquakes, explosions) and dissociation (Kuzucuoglu, 2014). Cultural heritage managed by museums has to be well preserved in order to make it available for future generations. For this reason, many researchers have focused on studying the risk factors and their effects on cultural heritage, both individually and through combination with other factors (Martens, 2012). At the same time, museums are constantly trying to improve their methods, techniques and tools of risk management (Tomaštík et al., 2020), so as to prevent the degradation of the cultural assets they possess.

Although some damages can be removed by restoration, it is much better to prevent their occurrence (Lucchi, 2020) for several reasons such as: (1) restoration costs can sometimes be much higher than those generated by preventive conservation; (2) the number of restorers is very low compared with the number of museum objects that need restorations and the volume of work involved; (3) certain risk factors cause irreversible degradations.

Based on these considerations, this paper aims to highlight how museums can use statistical analysis and diagnostic analysis for improving their conservation activities. A second aim was to present a modern solution used for monitoring and reducing the negative impact of two environmental risks, namely incorrect environmental temperature and relative humidity (RH). These environmental parameters are two of the most important factors that can put in danger museums' collections (Pavlogeorgatos, 2003; Sharif & Esmaeili, 2017). They are responsible for numerous damages of cultural goods, such us: chemical damages (corrosion, oxidation, discoloration, decreased mechanical strength), mechanical damages (delamination, deformations) and biological damages (fungi and bacteria growth) (Pavlogeorgatos, 2003). For

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this reason, keeping cultural heritage in a stable and controlled environment, without fluctuations of temperature and RH, is one of the most important goals of preventive conservation in museums (Kirby Atkinson, 2014). However, many museums have difficulties with ensuring a constant temperature and RH because of the high costs involved by this activity. Usually, they run in old buildings, with poor envelope, and their financial resources are never enough for covering all the expenses that should be done for keeping a stable microclimate in warehouses and exhibitions (Sharif & Esmaeili, 2017).

In this context, the next sections seek to highlight how small and medium-sized museums can find and put in practice solutions for improving their conservations activities through an adequate risk management.

Materials and Methods

The results presented in this paper are part of a larger risk analysis conducted according to the "SOBANE strategy for environmental risk management in museum buildings" (Lucchi, 2020). The first step of the research was to perform "a quick diagnosis of the building and the collection for identifying the most important potential risks" (Lucchi, 2020). After that, the risk factors were prioritized and an analysis of their causes has been done. In the end, several measures and recommendations for reducing the potential damages caused by identified risks were proposed. Since temperature and RH fluctuations are among the factors with the highest probability of causing damages, a deep analysis of microclimate was carried out.

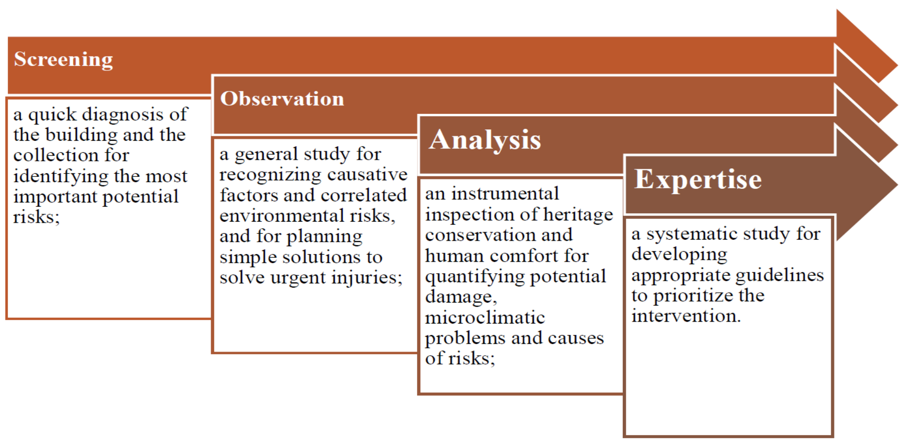

Fig 1. The SOBANE strategy for environmental risk management in museum buildings

Source: (Lucchi, 2020)

The statistical data referring to temperature and relative humidity were collected starting from 5th December 2018, until 19th August 2021 with the help of a digital data logger AXIOMET AX-DT100. The advantages of this device are given by the fact that it allows the recording and storage of temperature and RH values over long periods of time (stores up to 32,700 measurements). Afterwards, the data can then be downloaded to a computer for processing, analysis and interpretation. The accuracy of temperature measurement is ± 1 °C and the RH of ± 3.5%. The recording frequency can be set between 1s and 24h. Within the analyzed museum, the specialists in the field decided to test the microclimate parameters every 8 hours. Another important feature of the device is that it allows you to set an alarm if the temperature or RH exceeds a certain minimum or maximum value. This is done by connecting the device to the computer and accessing its dedicated software.

Results

Short description of the case study: County Museum of Art «Baia Mare Artistic Centre»

County Museum of Art «Baia Mare Artistic Centre» (CMABMAC) is the only museum in Romania which collects and exhibits works of art belonging to the Baia Mare School of Painting. The museum's collections include over 4,200 works of art illustrating European art from the eighteenth and twentieth centuries, as well as modern and contemporary Romanian art.

The building in which the museum operates is a historical and architectural monument of national importance. The basement and a part of the ground floor were built in 1748 for the Regional Office of Salt. In the basement were the salt depots, while on the ground floor were the offices. After a hundred years, the building become the headquarters of a bank and later the private home of the lawyer Teofil Dragoș. The upper floor was built at the end of the 19th century, and the large upstairs room was built in the middle of the 20th century. After the death of Teofil Dragoș, the building was donated to the City Council, which in 1954 decided to give it to the Maramureș County Museum. Later, the Art Division of the museum operated in the building, and, since September 2006, it has become the headquarters of the CMABMAC.

(a) **(b)**

Fig 2. County Museum of Art «Baia Mare Artistic Centre»: a) outside view b) inside view

The museum's cultural heritage

The cultural heritage of CMABMAC is structured in two categories: works of art and documentary archive. The works of art are divided in several collections: painting, sculpture, graphics, decorative art and art photography. Some of these cultural assets were purchased by the museum and are included in the public domain, while others were donated by artists or their families and are included in the private domain. In the case of the documentary archive, some donations are represented by catalogues, posters and leaflets created by the Art Division of the former Maramureș County Museum. According to the electronic inventory generated at 18.08.2021, the museum's collections have the following structure:

Table 1: The structure of the museum's cultural heritage at 01.01.2022

Collection / Source	Painting	Graphics	Sculpture	Decorative art	Art photography	Documentary archive	**Total**
Acquisitions	1441	2519	150	40	11	1970	**6131**
Donations	75	59	4	23	28	316	**505**
Total	1516	2578	154	63	39	2286	**6636**
Percent	22.85%	38.85%	2.32%	0.95%	0.59%	34.45%	**100%**

The largest share in the museum's collections is held by graphics (38.85%), followed by the documentary archive with a share of 34.45%. The high number of goods in the documentary archive collection (including: documents, vintage photographs, personal correspondence, memorials, catalogues and exhibition publications) is explained both by their relatively low price of acquisition compared with the price of a painting, and by the fact that they require a much smaller storage space than other categories of cultural goods.

The collection of documentary archive

According to their source of provenience, the documentary archive assets are structured in two categories: public domain and private domain. The public domain includes documents, photographs, negative photos / slide films, graphics, publications, medals, objects and accessories.

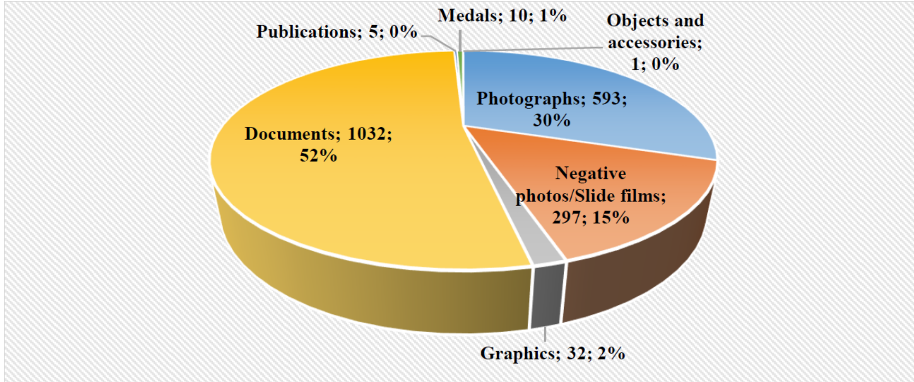

Fig 3. The structure of documentary archive – public domain

As it can be seen in Figure 3, over 99% of the goods included in the documentary archive – public domain are paper-based. The largest category is represented by documents which include manuscripts, letters, diplomas, posters, leaflets, brochures, invitations, IDs, receipts, press articles, magazines, catalogues, and other personal documents of some artists. In addition to the paper-based assets, the documentary archive contains 10 medals made from a mix of materials (metal, ceramics and textiles). Also, in 2018, the documentary archive was enriched with the eyeglasses that belonged to the artist Rudolf Schweitzer-Cumpăna (acquisition from the Artmark auction house). The documentary archive – private domain comprises 316 assets, of which 6 are photographs and 310 are publications.

The warehouse of documentary archive

The documentary archive is stored in a room located in the main building of the museum, on the ground floor, with an area of 6.97 m2. OSB shelves were mounted inside, attached to the wall with metal brackets and bolts. The window is covered on the inside with vertical blinds to partially block the light and is equipped with metal grilles. From the point of view of preventive conservation, a major problem of this space is the risk of flooding due to the fact that the warehouse is located near the toilets and the walls are crossed by water pipes.

The room is equipped with a radiator designed to ensure the maintenance of an optimal temperature during the winter, but does not have an air conditioning system. As the building in which this warehouse is located is an old building with thick walls, in the hot season the temperature does not exceed 29 ° C, which is why it has not been considered a priority to install an air conditioning system until now. Instead, this warehouse is equipped with a fire-alarm system, a powder-based extinguisher and a data logger for monitoring the temperature and relative humidity.

The main risk factors for collection

The identified risk factors for the documentary archive were classified according to their probability of occurrence as follows:

1. **Improper handling and storage**. Many documents in the documentary archive are in a precarious state of preservation, which is why any improper handling of them can easily lead to further physical damage.
2. **Incorrect relative humidity (RH).** The recommended values for RH differ as follows (Moldoveanu, 2009, p. 79; Canadian Conservation Institute, 2019): paper 30-50%; metal 25-30%; slide films 25-30%; goods consisting of a mix of materials (adhesives, textiles, metal, ceramics, glass) 50-65%. Since the RH in the warehouse is around 68% during the summer (see figure 4), this factor represents an important cause of degradation for the documentary archive.
3. **Incorrect temperature.** High temperatures increase the rate of chemical damage, provide activation energy for chemical processes (oxidation, foxing) (May & Jones, 2006), can stimulate the occurrence of biological attacks and reduce the number of years in which the paper loose half of its physicochemical properties (Moldoveanu, 2009, p. 129).
4. **Emissions of volatile organic compounds**. The OSB shelves contain adhesives that are a source of harmful emissions such as formaldehyde. Substances used for cleaning the areas around the warehouse may also contain ammonia. All these substances are a degrading factor for metals, textiles and paper (Padfield, 1966).
5. ***Pests.*** Fungi (Zonouz, 2018), bacteria (Pinzari et al., 2010) and insects such as silverfish, cockroaches and book lice (Trematerra & Pinniger, 2018; El-Hassan, 2021) can generate irreversible damages to cultural

objects (Brimblecombe & Querner, 2021). Their appearance is favored both by the high values of temperature and humidity in the hot season, and by the poor insulation of the warehouse.

6. **Internal degradation factors**. Lignin used in papermaking after 1850, ferro-gallic inks, acidic materials used for gluing, as well as inclusions of heavy metal ions (iron, copper) are the main internal factors that determine the degradation of paper (Moldoveanu, 2009, p 32).
7. **Unauthorized entry into the warehouse** (theft / vandalism). The analyzed warehouse does not have a video surveillance system and an alarm system. Therefore, the risk of degradation of cultural goods due to unauthorized entry into the warehouse is quite high.
8. **Improper lighting** (radiation). Exposing documents and books to light leads the occurrence of self-oxidation processes that have a negative impact on the paper strength (Daniels, 1986).
9. **Emergencies:** fires, floods, earthquakes, explosions.
10. **Dissociation**: Inaccessibility, inability to find the object, loss of object-related data and records, loss of object inventory number, relocation (Waller & Cato, 2016).

Microclimate analysis

Figure 4 reveals that for most of the year the temperature in the warehouse does not exceed the value of 20 °C (October - June). Minimum temperatures drop to about 10 °C in winter, while in the warm season the temperature rises to about 28 °C. In total, there were 78 days in which the temperature was above 22 °C.

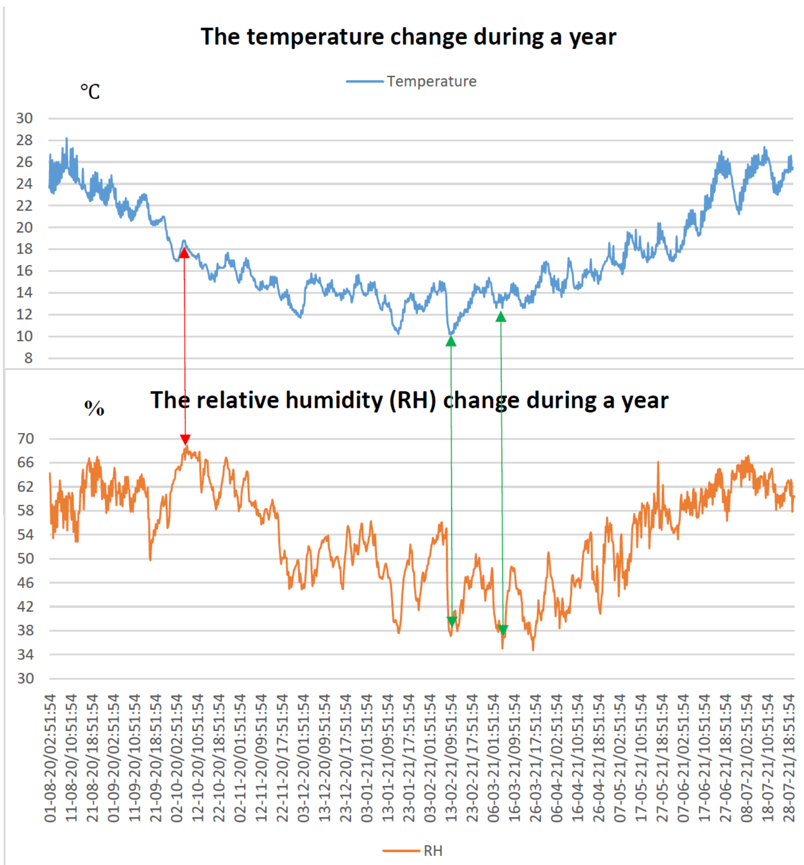

Fig 4. The dynamics of the temperature and relative humidity in the time frame August 2020 – July 2021

The second chart presented in Figure 4 shows that the RH does not usually exceed the maximum legal allowable value of 65%. Within a year, there were only 24 days in which the RH crossed this threshold. The highest values of this parameter were recorded in October, with a maximum of 68.9%, on October 7. The lowest values of RH are recorded in January-March, the minimum value reached being 34.7% (on March 25).

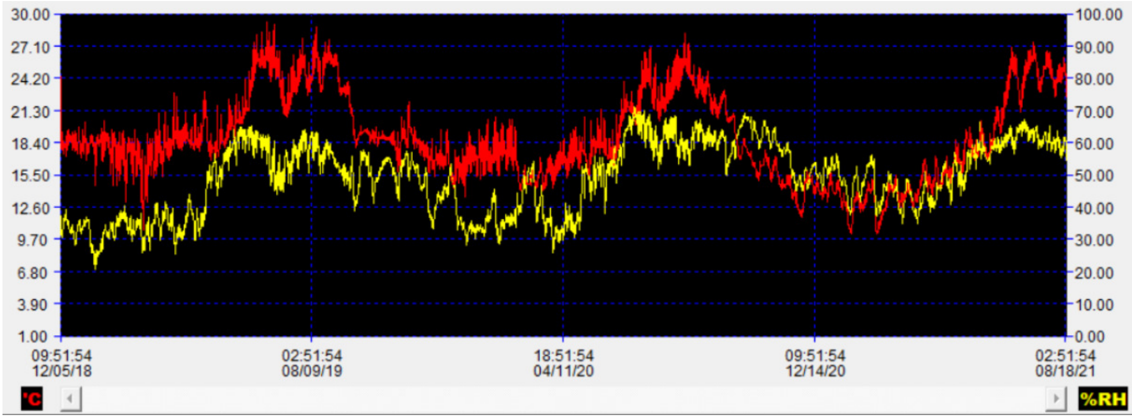

Fig 5. Microclimate monitoring chart generated by the Datalogger application (December 2018 - August 2021)

From the correlated analysis of temperature and RH dynamics we can see that in some cases (e.g., 13.01.2021, 13.02.2021) the decrease of RH happens concomitantly with the decrease of temperature. This is quite surprising if we take into account the fact that at a constant absolute humidity, the decrease in temperature causes the RH to rise and vice versa. Therefore, the evolution in the same direction of the two parameters can only be explained by the existence of a significant change in the absolute humidity in the warehouse. Specifically, the cold air entering the room had a lower absolute humidity than the previous absolute humidity in the room, which caused the RH to drop, despite the drop in temperature.

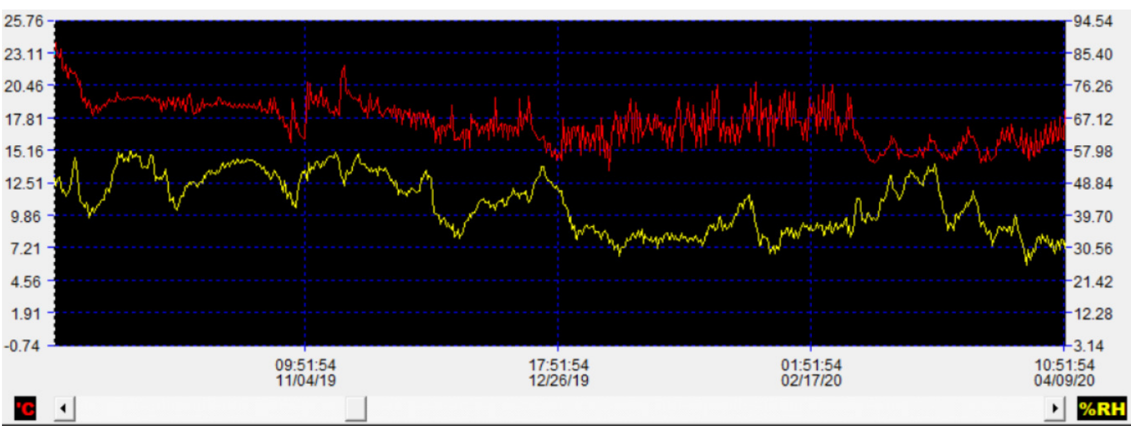

Fig 6. The dynamics of temperature and relative humidity in the time frame September 2019 – April 2020

In the cold season of 2019/2020, the strategy adopted by the museum was to use the heating system to maintain the storage temperature at a value of at least 15 °C (see figure 6). Although the temperature was kept at approximately similar values for seven months, it can be seen that this measure did not have a significant influence on the RH evolution. For instance, the temperature was quite stable (about 18-19 °C) in October 2019, but nevertheless RH ranged from 40% to 58%. In January-February 2020, the temperature usually ranged from 15-20 ℃. The increased temperature fluctuations in these months are probably due to the intermittent operation of the heating system. Although the maximum temperature was about the same as in October 2019, the RH was at a much lower level (30% - 40% versus 40% - 58%). Therefore, it can be stated that in this warehouse the RH is influenced by absolute humidity rather than temperature.

Based on these considerations, the radiator from the room was partially closed the following year. From Figure 7 it can be seen that this has led to a very similar trend of temperature and RH. Temperature usually ranged from 11-16 °C, and RH was in the range of 34% - 56%. The drop in atmospheric temperature has led to a drop in the RH because the water vapors in the air froze. When the outside temperature rose, this caused the snow to melt, which in turn led to an increase in humidity.

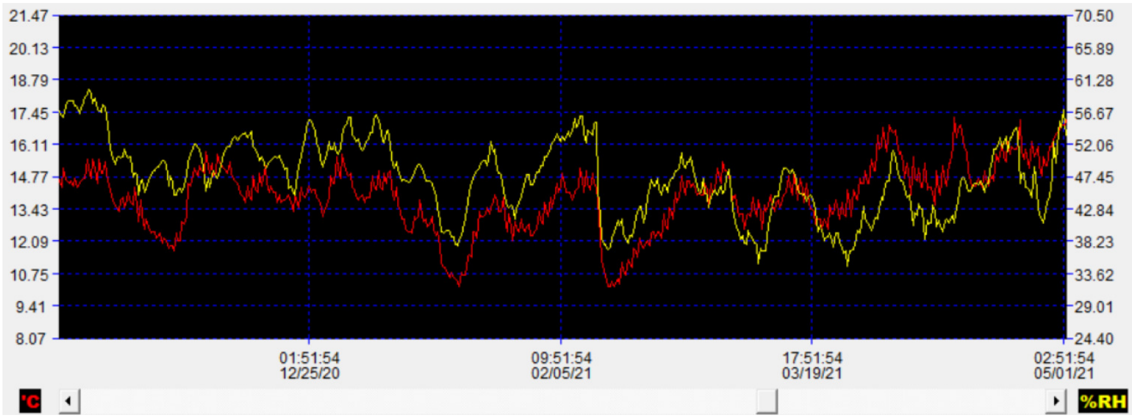

Fig 7. The dynamics of temperature and relative humidity in the time frame November 2020 – May 2021

In the warm season of 2019 (Figure 8) it is noted that there were many days when the temperature and RH changed in the opposite direction, most likely because of a constant absolute humidity. However, the analysis of the weekly and monthly variations reveals that the two factors have similar up and down trends in this case as well. Thus, even if during short periods of time the decrease of RH can be reached by an increase in temperature, in the long run this effect is offset by the much stronger influence of absolute humidity. Increased rainfalls and temperatures during the summer cause an increase in absolute humidity, which in turn leads to an increase in RH.

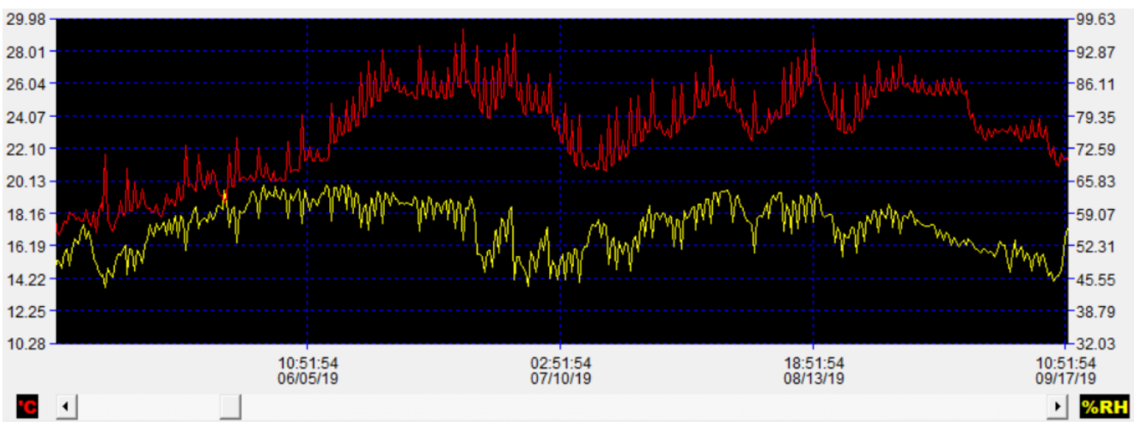

Fig 8. The dynamics of the temperature and relative humidity in the time frame May – September 2019

The same conclusions apply to the summer of 2020. For example, Figure 9 shows that, at certain times, the increase in temperature happened concomitantly with the decrease in the RH. However, by analyzing the data during one week we can note that both indicators have increased.

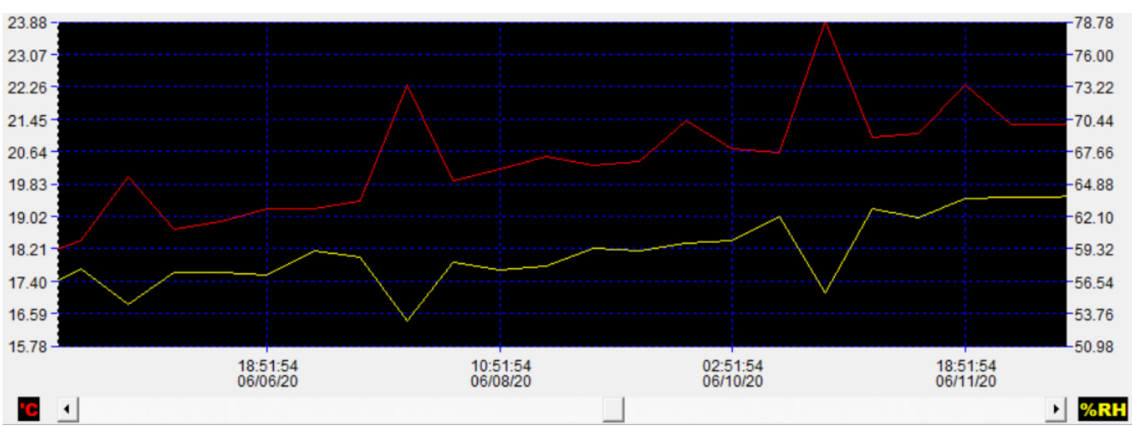

Fig 9. Weekly dynamics of temperature and RH (June 5-12, 2020)

Causes of microclimate fluctuations

The main cause of temperature and RH fluctuations is that the warehouse operates in a space that was not originally designed for this purpose. Although the building that houses the warehouse has quite thick walls, this does not provide a very high degree of thermal insulation. Therefore, atmospheric fluctuations in temperature and humidity are felt quite quickly inside the warehouse. Heavy rainfall and evaporation of water from the soil in the hot season cause an increase in the RH in the deposit. In the cold season, the absolute humidity in the atmosphere is low, which means that there is a decrease in RH in the warehouse as well. It is also possible that a part of the RH fluctuation to be generated by the evaporation of water used for cleaning the floor of the hallways situated near the warehouse. As the entrance door has no threshold, water vapors can enter the storage room very easily.

Fig 10. The warehouse entrance door

At the same time, microclimate fluctuations also occur due to the heating system used during the winter, which operates intermittently. This system serves not only the warehouse but also the bathrooms, the entrance hall and the museum's souvenir shop. For this reason, the temperature is usually set to a value of over 18 °C, so as to ensure optimal thermal comfort for visitors and employees. Therefore, when the thermal power plant is operating, a careful monitoring of the temperature in the warehouse is required, so as to prevent a heating of the space above the maximum limit allowed by the conservation norms. Keeping a low storage temperature in the warehouse can be achieved by partially closing the radiator. As can be seen from Figure 6, through this practice the temperature can be kept below 18 °C about eight months of the year (October-May). Last but not least, the lack of an air conditioning system negatively affects the microclimate conditions from the warehouse during the warm season (June-September).

Recommended measures for risks reduction

After identifying and analyzing the potential risk factors for the documentary archive collection, the next step was to propose several measures for reducing the probability of their occurrence. These measures are synthetized as follows:

1. **Improving microclimate conditions**:
   a) *Reducing the fluctuations of temperature and RH*, by: (1) reconditioning the storage window, so as to ensure a more efficient closing of it; (2) mounting a thick, opaque, thermally insulated panel on the inside part of the window; (3) replacing the entrance door with an airtight, fire-resistant door, or at least installing a sill to the existing door so as to prevent drafts, moisture and pests from entering inside; (4) thermal insulation of the warehouse; (5) installing an air conditioner device for keeping temperature and RH at a low level during summer; (6) using buffer materials which absorb moisture much faster than the cultural objects (silica gel, magnesium nitrate, sodium bromide) (Capotă, 2021);
   b) *Creating customized microclimate conditions* for different categories of goods in the collection. If this is not possible, then it is recommended to keep the objects together at a temperature of 15-18 °C and a RH of 30-40% (Moldoveanu, 2009, p. 155). The slide films can be stored in a box with microclimatic control (smart case), or at least in a refrigerator.

2. **Increasing heritage security and protection** by:
   a) Insulation of water pipes passing through the deposit with a waterproof material to reduce the risk of flooding in the event of cracks.
   b) Replacement of OSB shelves with electrostatically painted metal shelves or, ideally, with well-sealed metal cabinets;
   c) Installation of an inert gas fire suppression system and of a fire-resistant door;
   d) Equipping the warehouse with a video surveillance system and passive infrared sensors;
   e) Implementing a procedure for entering into the warehouse.

3. **Reducing the risk of a biological attack** by (Trematerra & Pinniger, 2018):
    a) Keeping the warehouse and surrounding areas clean in order to remove dust and other organic materials that may be sources of food for insects (Aak et al., 2020);
    b) Blocking all routes through which insects and rodents can enter the warehouse. All museum windows should be fitted with fine insect mesh nettings;
    c) Maintaining the RH below 60%;
    d) Inspecting periodically the collection to detect the occurrence of pests;
    e) Inserting books and documents in acid-free cardboard boxes (Moldoveanu, 2009, p. 469);
    f) Avoiding practices and habits that attract pests;
    g) Checking and keeping in quarantine cultural goods before introducing them into the warehouse;
    h) Isolating infested materials and applying the best methods for eradicating the infestation.

4. **Improving storage conditions** by:
    a) Equipping the warehouse with necessary materials for carrying out preventive conservation activities, such as acid-free cardboard boxes, sheets and paper envelopes;
    b) Reorganizing the storage system according to the nature, morphological type, format and size of the objects. During the reorganization process, the folded documents will be unfolded and they will be introduced in transparent paper envelopes with neutral pH. These envelopes will be stored in acid-free cardboard boxes.

5. **Improving the evidence system of documentary archive** by:
    a) Coding all the shelves, rows and boxes, creating a topographic catalog of the warehouse and writing in the digital inventory register the code of the place where each object is kept. In this way, the objects can be found very quickly even if they will no longer be sorted according to their inventory number.
    b) Creating a movement register for the goods leaving the warehouse. The existence of a movement register reduces the risk of dissociation and facilitates a more accurate record of objects;
    c) Preparation of conservation files and analytical records for all the goods in the collection;
    d) Registering all the objects in the DOCPAT program.

6. **Improving handling conditions** by:
    a) Implementing a procedure for handling the heritage objects;
    b) Using the digital version of the objects whenever is possible. In this regard, all the goods in the collection have to be digitized and the digital database has to be well-organized so as it can be easily used even by people who are not familiar with the structure of the collection.

Conclusions

The study presented in this paper is very useful for those museums that want to improve their conservation activity. The paper shows how data loggers, statistics and diagnostic analysis can be used together in the process of applying SOBANE strategy for environmental risk management in museums.

For many years museums could measure temperature and RH only with mechanical devices. The data were collected manually by conservators and very rarely someone performed long time analyses of these data, especially in small and medium-sized museums. Usually, when the allowed limits of RH were exceeded, the only measure taken was to use humidifiers or dehumidifiers to reach an optimum value again. Statistical analyses were hard to be performed because the only possibility to have the values in Excel was to introduce them manually, one by one. For this reason, the collected data were rarely analyzed.

Fortunately, the technological progress has simplified the procedure of temperature and RH monitorization. When the dataloggers were invented and became accessible for museums, an important barrier that existed in the way of a thorough statistical analysis of the microclimate parameters was removed. The advantage of data loggers is that they can memorize a large number of values and later the data can be exported in Excel.

However, many conservators continued their old habits of using the recorded values of temperature and RH, despite the great opportunity generated by the apparition of data loggers. Some museums didn't succeed yet to change their old devices with the new ones. Some others replaced the old devices with data loggers but this step has not been followed by proper analyses of the collected data. Only a small number of museums managed to exploit data loggers at their maximum potential.

Therefore, the main conclusion of this research is that monitoring microclimate parameters, taking measures to "repair" them (for example, through the use of humidifiers, dehumidifiers or air conditioning devices) and treating their effects is not the best solution for preserving cultural heritage. Instead, finding the root/primary causes of incorrect temperature / RH and eliminating them is a much better approach.

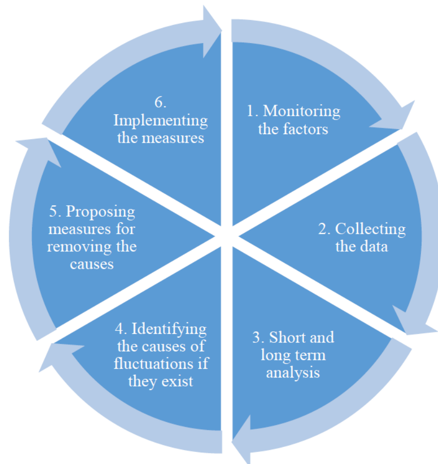

Fig 11. The process of microclimate risk management in museums

Many times, treating the symptoms of a disease has only a short-time benefit. Without finding and eliminating the causes of the disease, the problem is not completely solved and the patient will probably be sick again after the treatment ends, if the cause is still there. The same happens with the cultural heritage. If we wait until RH is too low or high, and, in that moment, the only thing we do is to use humidifiers / dehumidifiers, besides creating a high fluctuation of the parameter which is harmful for the collection, we do not really solve the problem because the incorrect RH will occur again after we stop the "treatment". Thus, for a proper microclimate risk management of the collection, the steps presented in figure 11 should be followed.

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