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Micro-climate control for paper heritage as a way of preventive conservation in museums

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Abstract

Some of the museum collections are archival materials which include unique manuscripts (the 1st primary source of knowledge). They are our invaluable documentary heritage of the past that reflect the rich cultural heritage like literature, history and medicine…etc. and must be preserved because of being irreplaceable for present and future generations.

Manuscripts are very sensitive materials that have to be preserved in a proper micro-climate showcases. They may rapidly deteriorate if they are put in bad conditions and might be lost forever. There are also additional factors rather than environmental control must be in consideration when thinking about manuscripts like light, security, vibration…etc.

Micro-climate is simply the condition inside an enclosed space whether in the whole museum (large area) or in a showcase (small area). By creating airtight cases that regulate the climate in a specific volume around an artifact. It differs in humidity, temperature and air cleanliness from the surrounding environment and also mechanical stability. It is important in the preservation of irreplaceable priceless artifacts to minimize the deterioration. That's why a controlled micro-climate keeps an ideal individual climate in a practical way than adjusting an entire exhibition, room or building climate.

Keywords

Micro-climate - Deterioration - Environmental control - Preventive conservation - Heritage.

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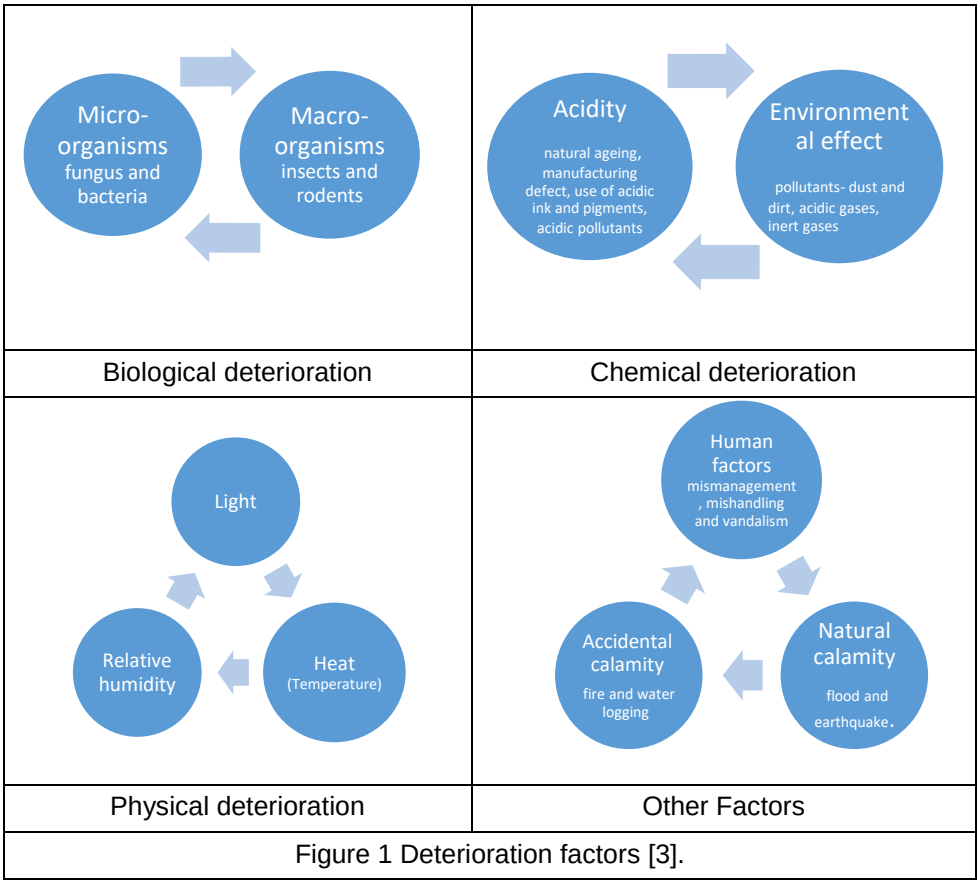
Introduction

Heritage science is a new approach of saving heritage as it focuses on increasing the understanding, use, care and management of cultural heritage in order to enrich people's lives today and in the future. Museums have an important role in society development, it increases the awareness and education of people.

The major factors causing deterioration to collections are the environmental effects in historic buildings. Manuscripts deteriorate rapidly by harmful environment agents such as temperature, relative humidity, pollution, light and pests cause its loss. It can be accelerated by inappropriate use, storage and display too [1], [2].

Figure 1 shows the main deterioration factors.



Biological deterioration	Chemical deterioration
Physical deterioration	Other Factors

Figure 1 Deterioration factors [3].

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Preventive conservation

Nowadays, preventive conservation is important to minimize and avoid future damage to the object, they are carried out from the surrounding of an object. Actions and measurements are indirect without any interfere with the structure, material or appearance modification of the object to promote the long-term preservation of cultural property [5], [6].

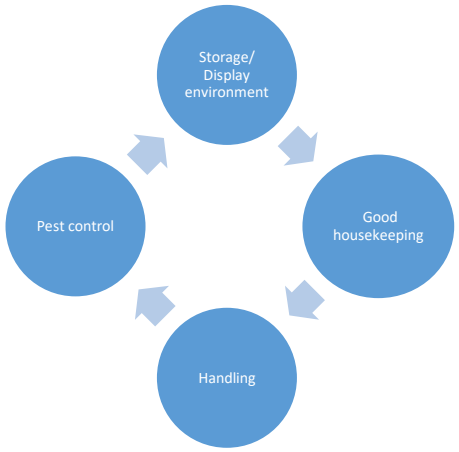

Figure 2 Preventive conservation measurement [4].

Figure 2 shows the main measurements of preventive conservation.

Display Environment

Environmental factors like Relative humidity and temperature affect museum objects in three degradation processes: chemical, biological, and mechanical. Organic materials chemically deteriorate easily. As temperature increases, moisture also increases in the air. Every artifact requires an ideal environment but there isn't a fixed ideal range of relative humidity for all objects [7], [8]. Figure 3 & 4 shows the effect of Relative humidity & temperature on manuscripts.

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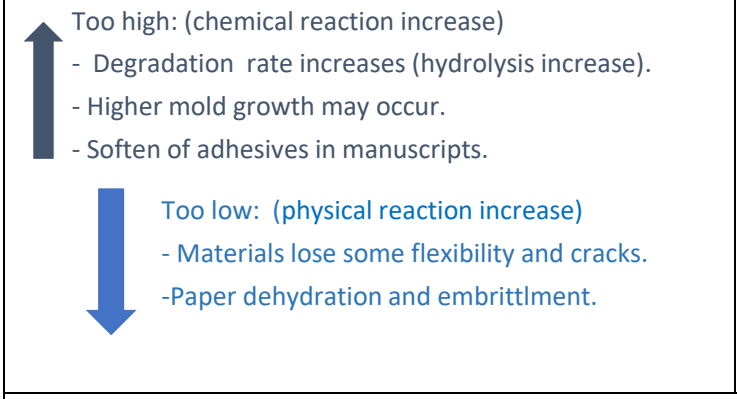

Figure 3 Relative humidity's effect on manuscripts [9], [10].

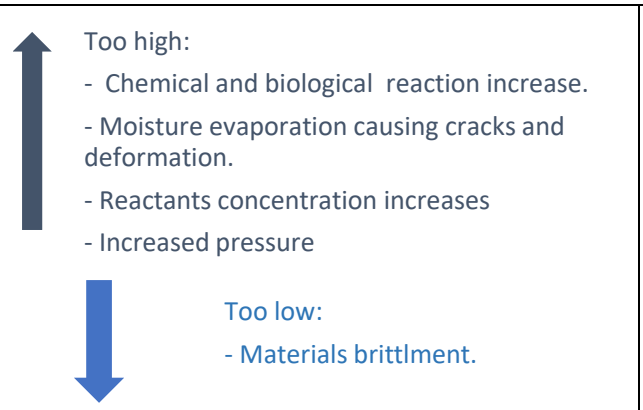

Figure 4 Temperature's effect on manuscripts [9], [10].

Building management system

One of the preventive conservation basics is building management system. As it controls and monitors the building's mechanical and electrical equipment such as lighting, ventilation, fire systems, power systems, housekeeping system micro-climate system, and security systems through a computerized system that is installed in museum buildings [11].

Careful museum housekeeping needs the correct supplies and equipment with proper techniques for the preservation of a collection. Regulated and scheduled daily, weekly, monthly, quarterly, semi-annual and annual housekeeping means that dirt is unavailable so that deterioration will not take place [12], [13].

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Gaseous and particulate air pollutants are very harmful to collections. Gases such as hydrogen sulfide, sulfur dioxide, nitrogen oxides, and ozone are absorbed from the air into papers. These gases in the atmosphere react with the moisture in paper to produce acids that increase the rate of paper deterioration, fiber structure break down, and cause embrittlement. Not only gaseous pollutants that are harmful but also particulate pollution that is made up of ash, dust, smoke…etc. It disfigures and obscures text, also increases the presence of acidity and mold spores shown figure 5 [1], [9].

Particulate pollutants	Gaseous pollutants
• Attract moisture. • Attract pests.	• Reacts chemically with materials. • Oxidizing agent: fading pigments. • Acidity: yellowish and embrittlement of paper.

Figure 5 Pollutants effect on organic objects.

Manuscripts are sensitive to light and can't be displayed under natural lighting. Light causes fading of dyes and inks; yellows paper and weakens the cellulose fibers through oxidation. It can also brittle paper from dehydration. Time of exposure must still be controlled even with the low light levels in exhibition galleries as light damage is cumulative [1], [9], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23].

Handling

Manuscripts are delicate when they are deteriorated. Poor handling may cause more damage to the manuscript [24]. Before handling any object, hands should be washed and dried to avoid dirt and oils. Gloves obscure material sensation, they are worn only for staff protection if needed. It is recommended to wear unpowdered fitted vinyl gloves to avoid latex allergy problems. Cotton gloves are not preferred as they absorbents and transfer dirt to objects. Objects must be put on clean surface. Use appropriate book cradle underneath the object and use special weights if needed [25], [26], [27], [28].

IPM in a museum and library

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A well planned and executed IPM programme in figure 6 will prevent problems or crises occurring and, in times of restricted budgets, will make much more effective use of limited human and cash resources. The key to successful pest control is denying where they can live and reproduce and developing procedures. Keep pests out of the building by blocking their access to the building and collections. Identify the most harmful species. Assess the problem based on inspection and trapping, and identifying the high-risk parts of the collection and building. It is also important to understand pests' life cycle, especially insects. Solving pest problems by environmental improvement by carrying out appropriate treatments and discouraging the pests. This should include pest identification, documentation, training and funding resources, as well as surveys and treatment of infestations [29].

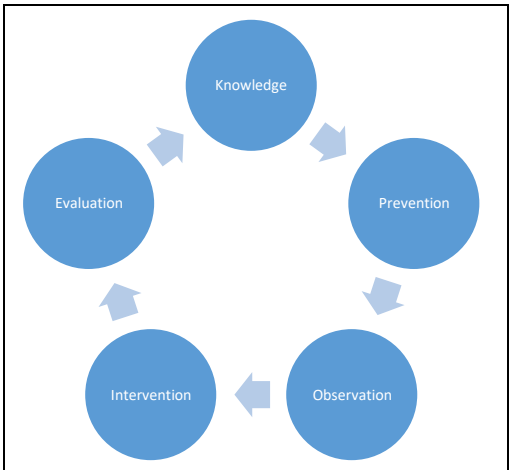

Figure 6 IPM basic strategy [30].

Micro-climate control

Micro-climate is simply the condition inside an enclosed space whether in the whole museum (large area) or in a showcase (small area). By creating airtight cases that regulate the climate in a specific volume around an artifact. It differs in humidity, temperature and air cleanliness from the surrounding environment and also mechanical stability. It is important in the preservation of irreplaceable priceless artifacts to minimize the deterioration of these artifacts. That's why a controlled micro-climate showcase keeps an ideal individual climate in a practical way than adjusting an entire exhibition, room or building climate [31], [32]. Figure 7 shows the important points in decision making for better climate control.

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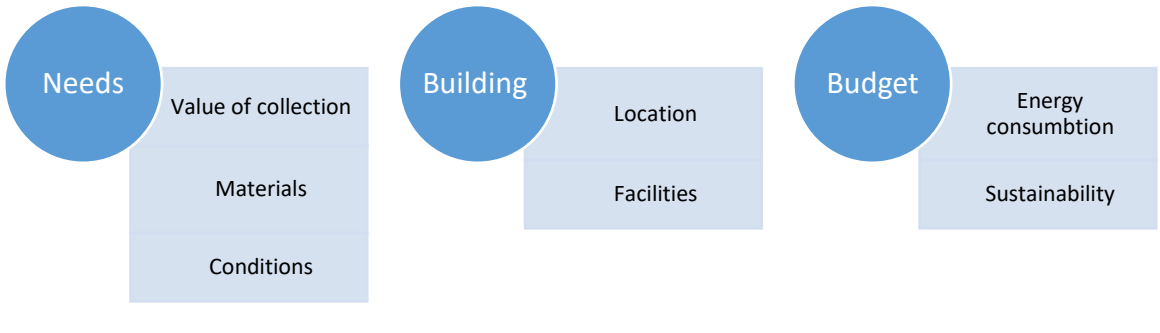

Figure 7 Decision making for climate specification [33].

Different materials have different recommended relative humidity and temperature and set point. It has been shown that lowering temperature and relative humidity will increase the life of organic materials. Relative humidity should never fluctuate rapidly. By lowering temperatures longevity of collections greatly increase, but are very hard on museum visitors [7].In figure 8 & 9 the recommended relative humidity and temperature for manuscripts.

Contents	Relative humidity	Fluctuation (+ or -)
Manuscripts and paper	40 - 60 %	3 %

Figure 8 Relative humidity Recommendations for hygroscopic materials [9], [34], [35].

Contents	Temperature	Max
Manuscripts	18-20° C (64-68° F)	24° C (75° F).

Figure 9 Temperature recommendation for hygroscopic materials [35], [36], [37], [38].

Also, the volume of pollutants in museums must be careful monitored [39], [40]. Various filter solutions are available, controlling harmful pollutants by filtration offers a particularly cost-effective method [41]. Air filter should be installed to prevent entering of pollutant gases inside the display areas. Filters of aluminum impregnated with potassium permanganate and HEPA filters are best [9].

Particulate pollutants	Gaseous pollutants
HEPA filters are the best suited in closed small areas.	Filters of aluminum impregnated with potassium permanganate or activated charcoal.

Figure 10 Recommendation of particulate and gaseous pollutants [9], [42].

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Fiber optic lighting or LED are convenient systems for manuscripts displaying in museums. They produces negligible heat. OLED are being studied nowadays to be the next generation source of light of organic material. Manuscripts folio opening are rotated on a regular basis and the light levels for the display of illuminated manuscripts are kept low in galleries (50 lux) (figure 11). Showcases provide internal lighting projected downward from fiber-optic light sources installed above the display area of the case [1], [9], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23].

If the museum doesn't have light or UV meter, it is also possible to estimate artifact damage that might occur by using ISO's Blue Wool standard cards. Each Blue Wool standard consists of eight blue-dyed wool samples with different sensitivity to light [16] .

Type of space	Light level range
Display	50-150 lux. Short exposure are recommended for paper and sensitive materials.

Figure 11 Recommendations of light in displays based on 8 hours/day and maximum 60-90 days [9], [15], [17], [22], [23].

Figure 12 ISO's Blue Wool standard cards [43].
Where sample 1 is extremely sensitive to light, while sample 8 is the most stable dye [16].

Other factors

The manuscript showcase should be designed to move as a unit if there will be a natural hazard like earthquakes. The case itself should be anchored directly to the floor with bolts, the display deck is secured to the interior of the case, and the cradle is pinned to the display deck [15]. Floor should be isolated with a suitable material that avoids vibration like Sorbothane [44].

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Tight fitter doors, high quality locks and adequately sealed joints are to be provided with materials which doesn't damage the exhibited object [14]. Locking equipment's for example ABLOY® Cam Locks now meets the highest levels of security [45].

In display cases, background color should create a clear visual access to displayed objects without affecting displayed objects [46]. Manuscripts must be rested on cradles and could be rested also on cushioning materials such as ethafoam and polyethylene foam [15], [44]. A tilted cradle to view the open manuscript on display is designed to maximize visitor's ability. The cradles have an inclination angle of 30° for manuscripts if it's in a best condition, with a 15° or 20° tilt used for weak sewing structures. The inclination angle depends on the kind of the manuscript and its sewing structure. The manuscript should be strapped with polyethylene strapping to the cradle at outer margins of the folio [15].

Conclusion

It is important to save historical materials for further generations to understand their past. The challenge in any museum is to preserve the manuscripts and prevent them from damage. That's why designing and setting up an exhibition takes an extensive amount of time, careful planning, and finances. While the adventure is beneficial to the public, care must be taken to ensure the manuscripts are not damaged during the exhibit.

Manuscripts gallery should not contain any window. Types and dimensions of cases depends on the selected object. Particularly for manuscripts exhibition it is preferable the horizontal case with a glass top (for displaying objects and for protection against damaging agents like dust, insect, general climate, light, visitors, and vandalism) through which objects are looked at. The glass should be (a) laminated glass, less than 1% reflection & up to 99 % (b) UV blocking. The height of the case is usually about 15 cm deep on a table about 75 cm high. But also the vertical case are accessible and found in many museums around the world [47], [48],

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[49]. All manuscripts must be rested on cradles in order not to break the sewing structure depending on the kind of manuscript [15], [50].

Display cases, mounts, frames and other display devices should be constructed with high-quality, chemically-inert 'safe' materials, be reasonably well sealed to minimize air and water leakage [9], [15]. It is also recommended to use Ammonia-free cleaner is to be sprayed onto a micro-fiber cloth for cleaning [49].

Good environment control monitoring system is essential and recommended to use in order not to affect the delicate written inks and pigments that are the main compose of the manuscript. The gallery must be kept at the same relative humidity and temperature conditions as the storage area of special collections. Rooms are designed with darkened lighting that enhances the ambiance of the space. During exhibiting relative humidity, temperature, and light should be monitored by data loggers and are automatically recorded so pigments will not fade, crack or bleed. HVAC is an ideal example of maintaining optimum temperature & humidity for the storage and displays. As a precaution against active control like HVAC failure, passive control of silica gel like Art-Sorb® cassettes are always present in the showcase drawer so pigments will not fade or bleed [15]. But in case of metallic ink it is preferred to use PROSorb cassettes [51], [52].

Air filters are essential to reduce harmful pollutants. Low heat transmitter light like LED and fiber optics are the best in showcases and preferable a visitor sensor to reduce the exposure time [2], [53]. IPM strategy is also important in museums in order to prevent the attack of materials and artefacts by (a) insects and other 'animal' pests and (b) by fungi and other microbiological agents [1], [54]. In the end, all these precautions are done trying to save precious manuscripts and prolonging their lives as much as possible.

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