Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

Methods of Preservation and Display of Composite Materials at the Rusicade Municipal Museum, Skikda

Zaitri Ali[1]

Abstract

This study examines the conservation and restoration of composite materials preserved at the Rusicada Museum in Skikda, Algeria. It highlights the significance of safeguarding archaeological objects composed of different materials, such as metals, wood, glass, and ceramics. The study discusses the challenges encountered in the conservation process due to the diverse physical and chemical properties of these materials and their interactions with environmental factors, including humidity, temperature fluctuations, and pollution. It also reviews the methods used for examination and diagnosis to identify deterioration phenomena, as well as the cleaning, consolidation, and restoration techniques employed while preserving the authenticity and historical value of the artifacts. The study emphasizes that preventive conservation and proper environmental control within museum spaces are essential for protecting archaeological collections and extending their lifespan. These measures contribute significantly to the preservation of cultural heritage and ensure its transmission to future generations.

Keywords: *Conservation and Restoration; Composite Materials; Preventive Conservation; Cultural Heritage; Archaeological Artifacts; Rusicada Museum; Museum Collections Preservation.*

Received : 23/05/2026

Introduction

Archaeological composite materials constitute some of the most significant material evidence reflecting the evolution of technology and craftsmanship across historical periods. These objects are composed of two or more distinct materials that were combined to form a single artifact with a specific function, possessing both aesthetic and historical value. Historical weapons, such as antique firearms, serve as a particularly illustrative example of composite heritage materials: they are typically constructed from a combination of inorganic components, such as iron, and organic components, such as wood and leather, making them a paradigmatic case study in composite material conservation.

These archaeological objects carry considerable aesthetic and historical significance, not merely as functional tools of the past but as tangible manifestations of the technological and industrial development of the societies that produced them. They reveal the skills of craftsmen and illuminate the manufacturing and decorative techniques prevalent during the Ottoman period.

Given the heterogeneous nature of composite materials, their display and long-term preservation in museum settings require specialised attention with respect to both conservation methods and exhibition practices. Museums employ contemporary techniques aimed at enhancing the aesthetic and archaeological value of such objects, including the regulation of lighting, humidity, and temperature, as well as the use of specialised display cases. Because these materials (particularly wood and leather) are especially vulnerable to deterioration, the diversity of their constituent components renders them more susceptible to damage when environmental conditions are inadequate, particularly regarding temperature, relative humidity, and light intensity within exhibition halls. The conservation of such objects therefore represents a significant challenge for museums, requiring the establishment of precise environmental parameters that ensure material stability and mitigate deterioration.

[1] Sharif Bouchoucha University Center - Aflou -(Algeria), E-mail: a.zaitri@cu-aflou.edu.dz

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

This study aims to examine the nature and properties of composite materials, with a particular focus on historical firearms. It also investigates the influence of environmental factors (including temperature, relative humidity, and light) on the condition of archaeological objects, and seeks to identify appropriate environmental standards compatible with both the display and preservation of these materials within the museum and its exhibition halls.

The central research question that emerges from this context is as follows:

What environmental conditions with respect to temperature, relative humidity, and light intensity must be established within museum settings to ensure the preservation of composite archaeological objects, such as historical firearms, and to prevent their deterioration?

The Rusicade Museum

The museum building occupies an area of 2,726 m² and is composed of three wings. The first (central) wing contains two galleries: the ground floor gallery is dedicated to archaeology, while the first-floor gallery is devoted to modern art. The second wing, located on the northern side, comprises a ground floor gallery housing the numismatic collection, which contains 7,000 items including coins and medals; this wing also accommodates the museum curator's office. The third and final wing, situated on the southern side, contains a ground floor gallery dedicated to arms and a first-floor gallery for naval weapons. This wing was designed by architect Jean Baptiste Martin, who also designed the museum's front garden and perimeter fence.

At the time of its establishment, the museum was considered among the wealthiest in Algeria, housing 1,500 diverse archaeological objects: 61 columns, 52 column bases, 106 column capitals, 9 large statues, 6 half-statues, 8 small statues, 15 sarcophagi, all in marble, 174 inscriptions, as well as numerous ceramic fragments, glass pieces, mosaics, and ancient tools (Bertrand, Louis, 1903).

To this day, this museum space remains under the supervision of the Skikda municipality, awaiting the long-anticipated establishment of a scientifically designed museum capable of properly accommodating its archaeological collections.

Museum Functions

The collections held by the museum, whether acquired through excavation, purchase, exchange, or donation, represent one dimension of the exhibition process. Display constitutes the primary means and most effective instrument for achieving the museum's principal objective: the education and cultural enrichment of the general public, regardless of social affiliation or age group. This goal is shared by all contemporary museums (Muhi al-Din Shibli, 2008).

Effective museum display relies first and foremost on sound judgement and a refined aesthetic sensibility, which together contribute to a lasting impression on the visitor. Quality exhibition does not merely concern itself with the preservation of archaeological artefacts; it extends to the presentation of objects in a manner that is both accurate and visually engaging, while maximising the informational value of the displayed items as vehicles for the transmission of knowledge and culture.

In order to achieve these objectives, museum administrators must take into account several factors of considerable importance to the exhibition process, including:

The Museum Building

Museum staff are required to familiarise themselves with the architectural plan of the institution and identify both its strengths and limitations, so that the layout serves the intended goals of display and facilitates the smooth movement of visitors through the collections[i]. The building must provide dedicated gallery spaces for the display of archaeological finds, a library, a lecture hall, administrative offices, and, where possible,

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

an outdoor garden (Rif'at Mohamed Mousa, 2002), in which artefacts not susceptible to weathering and deterioration may be displayed.

Particular challenges arise in the display of composite collections, that is, objects composed of more than one material such as weapons and firearms. Display standards designed for single-material objects are insufficient for such items, as they cannot adequately address the specific conservation requirements needed to protect composite artefacts from all forms of deterioration.

Description of the Museum Collection

The museum collection under examination comprises more than 19 rifles and two pistols. This collection is housed in the fifth gallery of the museum and is displayed in both horizontal and vertical glazed cases. The museum is organised into five galleries, each subdivided into left and right wings. The fifth wing contains a collection of weapons, including:

- ✓ 19 rifles from the former arms wing of the museum
- ✓ A pirate-type pistol dating to the second century
- ✓ A military flintlock rifle

Figure 2: A Military Flintlock Rifle.

Through site visits to the museum and systematic observation of the display conditions, the state of preservation of the artefacts, their spatial distribution throughout the institution, and their methods of presentation, a number of significant observations were recorded.

Part One: The Influence of Environmental Factors on Composite Materials

1. The Effect of Relative Humidity

Relative humidity is considered the most hazardous environmental factor affecting composite materials, owing to its direct yet differential impact on their various components:

- ✓ Wood and leather are hygroscopic materials that absorb and release moisture, leading to expansion and contraction. Rapid fluctuations in humidity cause cracking in wood and dryness and brittleness in leather.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

✓ Iron is highly susceptible to elevated relative humidity levels (above 40–50%), which accelerate corrosion and chemical oxidation, weakening the metal structure and eventually leading to its fragmentation.

✓ The principal challenge lies in the conflicting requirements of the constituent materials: iron requires a dry environment with very low humidity, whereas wood and leather require moderate humidity levels to prevent desiccation and embrittlement.

2. The Effect of Temperature

✓ Elevated temperatures accelerate the degradation of organic materials (wood and leather) and promote harmful chemical reactions.

✓ Thermal fluctuations cause differential rates of expansion and contraction in iron and wood, which may result in the mechanical detachment of components within a single object, such as the separation of iron nails from wooden elements.

3. The Effect of Light

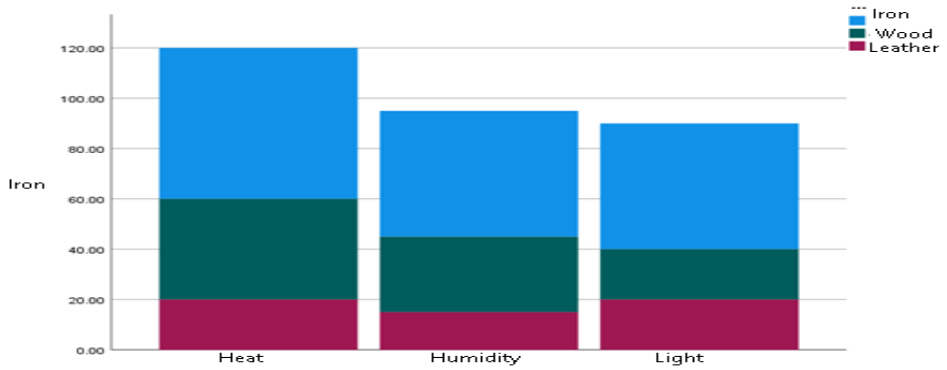
✓ Light, particularly ultraviolet (UV) radiation, causes irreversible damage to organic materials.

✓ Prolonged light exposure leads to the fading of leather, discolouration of wood, and the weakening of surface fibres through photochemical degradation.

Table 1. Comparative Tolerance Thresholds of Composite Materials to Environmental Factors

	Iron	Wood	Leather
Temperature (°C)	60	40	20
Relative Humidity (%)	50	30	15
Light Intensity (Lux)	50	20	20

Figure 1: A stacked bar chart comparing the recorded values for the environmental factors under study (temperature, relative humidity, and light intensity) and their effects on the museum materials examined (iron, wood, and leather).



The data indicate that iron recorded the highest values across all environmental variables: its temperature tolerance reached 60, compared to 40 for wood and 20 for leather. This disparity reflects the greater capacity of metallic materials to withstand thermal variation relative to organic materials. With respect to relative humidity, iron maintained a comparatively high tolerance value of 50, versus 30 for wood and 15 for leather, indicating that organic materials are more susceptible to moisture owing to their hygroscopic nature, which predisposes them to dimensional changes and mechanical deterioration. As regards light sensitivity, iron

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

demonstrated the lowest response at a value of 50, while wood and leather both recorded values of 20, reflecting the susceptibility of organic materials to photochemical degradation over time.

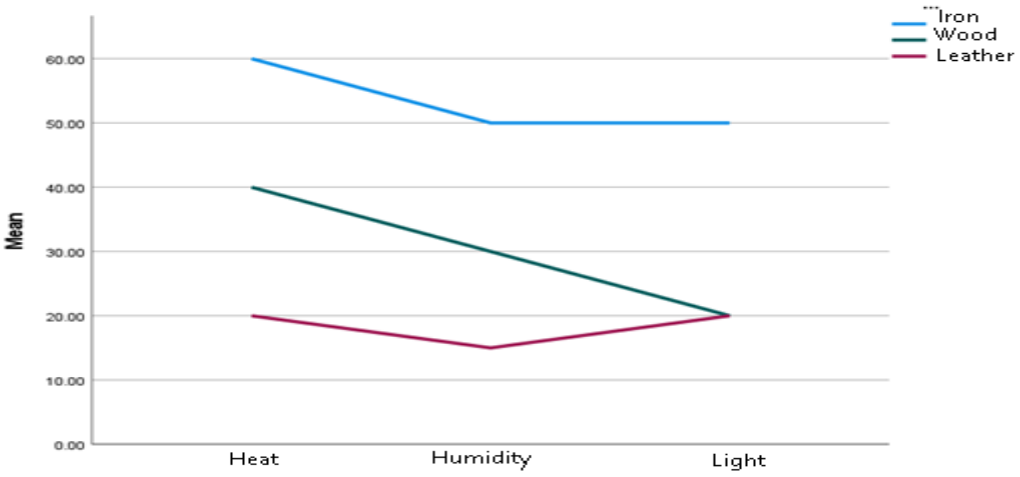


Figure 2: A line graph presenting the same data in a format that illustrates the trajectory of change across the different environmental variables.

The iron curve remains at the highest level throughout all measurements, beginning at 60 for temperature and declining slightly to 50 for both humidity and light, indicating relative stability in response to environmental change. The wood curve shows a gradual decline from 40 at temperature to 30 at humidity and 20 at light, reflecting the sensitivity of cellulosic materials to environmental variation, particularly moisture. The leather curve records comparatively lower values (20 for temperature, 15 for humidity, and 20 for light), consistent with its nature as a proteinaceous organic material. These graphical representations collectively confirm that organic materials such as wood and leather are significantly more vulnerable to environmental deterioration than metallic materials, necessitating precise conservation conditions in museum storage and display contexts.

Part Two: Methods of Preservation and Display within the Museum

To address the conflicting conservation requirements of composite materials, the following strategies are recommended:

1. Microclimate Display Cases

Rather than attempting to regulate the ambient climate of an entire gallery, it is preferable to create a controlled microenvironment within sealed display cases. The cases are hermetically closed and fitted with humidity-regulating materials, such as silica gel, to maintain a stable relative humidity level appropriate to all components of the composite object (typically around 45–50% as a compromise value).

2. Absorbent Materials and Buffers

➢ Silica gel: used to absorb excess moisture or compensate for moisture deficiency, thereby maintaining environmental stability.

➢ Activated charcoal: used to absorb pollutant gases that may be emitted by wooden elements or the surrounding atmosphere and could promote corrosion of iron components.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

3. Contemporary Lighting Techniques

- LED lamps are recommended, as they emit no ultraviolet radiation and do not raise the temperature inside display cases.

- UV filters should be applied to windows and all light sources.

- Light intensity should be restricted to a maximum of 50 lux for light-sensitive materials such as leather and wood.

4. Continuous Environmental Monitoring

- The use of data loggers to continuously record fluctuations in temperature and relative humidity is essential. This enables prompt intervention whenever environmental conditions deviate from the established standards.

Part Three: Managing Conflicting Conservation Requirements

When an object contains both iron and wood, the recommended approach is as follows:

- Priority should be given to the material most susceptible to rapid deterioration. If the iron component exhibits active corrosion, humidity should be reduced while the wooden component is carefully monitored to prevent excessive desiccation.

- Selective isolation: in certain cases, metallic components may be coated with thin protective layers (such as Renaissance wax) to isolate them from the ambient humidity required by the wood and leather components.

- Environmental stability is more critical than achieving theoretically ideal conditions. Materials adapt to stable environments even when those environments are not perfectly optimal; it is sudden fluctuations that cause the most significant damage.

Assessment of Conservation Conditions

The current state of conservation at the museum is assessed as entirely deficient. Given that the museum holds a collection of diverse artefacts requiring varied and specific conservation conditions, several fundamental conservation requirements have been found to be disregarded. Adequate resources and attention to the conservation needs of each object, with respect to its materials, nature, and current condition, are manifestly absent.

The first step in treating composite weapons (composed of iron, wood, and leather) is a diagnostic examination to assess the state of preservation of each object. This assessment serves as the basis for determining the necessary interventions (corrosion stabilisation, structural consolidation, cleaning) and for establishing the appropriate techniques to be employed.

Lighting

Lighting is an essential element in the success of museum display and the achievement of its objectives. In museum practice, two principal categories of lighting are employed:

Natural Lighting

Natural lighting is divided into two types: direct sunlight and diffused skylight. Each has its advantages and disadvantages with respect to displayed objects; however, natural lighting is unavoidable in institutions with open or transparent structures.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

Artificial Lighting

Artificial lighting may be employed in museums where natural light is absent, whether due to evening opening hours or the absence of windows, and is particularly appropriate where exhibited objects, such as leather and wood in weapons collections, are sensitive to light. It offers the advantage of being easily controlled and maintained at stable levels. Neither of these lighting options is adequately provided at the Skikda Municipal Museum, which has exposed the displayed objects to preventable deterioration.

Direct artificial lighting, directed from a light source straight onto displayed weapons, produces shadows and glare on object surfaces, particularly on metallic elements. This is considered a significant drawback from a display perspective and poses a serious risk to the integrity of museum objects [ii].

Display Fixtures and Cases

Display fixtures refer to the showcases used as locations for the presentation of archaeological finds and artistic objects. With specific reference to the display of light arms collections, namely rifles and swords, two principal types are employed at the museum:

Central Display Cases

These cases are positioned at the centre of galleries, as observed at the Skikda Municipal Museum. They are characterised by varied forms that allow visitors to view the displayed objects from multiple angles.

Wall-Mounted Display Cases

Museum collections are exposed to a wide range of potential damage arising from their use (display, study, storage), as well as from inappropriate handling and inadequate environmental conditions, including temperature, humidity, light, and chemical pollutants. These factors interact with the constituent materials of objects in accordance with the sensitivity of each material, resulting in various forms of deterioration such as colour fading and metal oxidation. It is in response to such risks that preventive conservation must be implemented[iii].

The conservation of museum collections requires a thorough understanding of the objects through physical examination and scientific and historical documentation prior to and during their intake by the museum. This includes identifying the nature of the constituent materials (organic, inorganic, or composite, as in the case of weapons), understanding their internal structural characteristics, documenting the original environment, the history of deterioration, and any previous restoration treatments. This information is recorded on object cards or institutional registers and constitutes what is known as documentation, which forms a fundamental component of any preventive conservation programme (Rif'at Mohamed Mousa, 2002).

Preventive conservation is grounded in two principles, namely precautionary conservation and the axiom that prevention is preferable to treatment[iv], with the following primary objectives:

- Objects must not be placed directly on the floor; they must be housed in display cases appropriate to their specific conservation requirements.

- Stacking of objects within drawers is to be avoided; each object should be stored individually.

- Adequate spacing between objects must be maintained to allow handling, access, and air circulation.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

➢ Regular cleaning of objects should be carried out: dust and surface dirt are to be removed outside the storage room using soft, dry brushes and a vacuum cleaner equipped with a comprehensive filtration system. The use of solvents or other cleaning agents should be avoided[v].

Inspection and Maintenance

The implementation of periodic inspection procedures is essential for monitoring the condition of objects and identifying emerging problems. Well-organised and properly maintained display cases reduce the risk of deterioration. Monitoring should be conducted on a daily or weekly basis and requires no significant effort or resources.

Environmental monitoring and the protection of composite objects (iron, wood, leather) necessitate the adoption of appropriate climate control measures, whether within the museum or any other storage facility, and the application of targeted interventions suited to the specific properties of each material type. This ensures their protection, longevity, and long-term structural integrity.

Protection from heat and humidity requires the installation of standardised measuring instruments in close proximity to the museum collections, positioned away from the public, sources of pollution, dust, and ventilation openings, thereby facilitating accurate and continuous recording.

Preventive Conservation Equipment

Portable Thermo-Hygrometer

This instrument consists of a display unit and a sensor probe that measures both temperature and atmospheric relative humidity. It is used for the daily monitoring of the microenvironments surrounding archaeological objects as the operator moves through gallery and storage spaces.

Graphic Thermo-Hygrograph

This instrument is placed in exhibition or storage rooms to record fluctuations in relative humidity and temperature separately. It operates by means of two pens, each a different colour, tracing continuous readings on millimetric paper divided into seven sections corresponding to the days of the week, with each section further subdivided into 24 hourly intervals. This system enables the retrieval of precise daily and weekly data on humidity and temperature variation.

Display Case Thermo-Hygrometer

Distinguished by its compact dimensions, this device is designed for use inside display cases to monitor micro-level humidity and temperature conditions. Readings are accessed via a digital screen.

Objectives of Environmental Measurement

The purposes of systematic environmental measurement are as follows:

✓ To carry out corrective adjustments to climatic conditions through the use of humidification and dehumidification devices.

✓ To ensure appropriate management of all conservation factors.

✓ To enable thorough knowledge of the building's climate, allowing for the diagnosis and evaluation of temperature and humidity levels within rooms.

✓ Where the building is air-conditioned, to modify the internal climate through the centralised control system, which regulates temperature and humidity.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

✓ Where the building is not air-conditioned, to employ seasonal regulation devices positioned away from the collections to prevent the creation of an unsuitable microclimate.

Through the use of display case thermo-hygrometers, humidity and temperature readings are recorded individually for each display or storage unit. This allows for the determination of the extent to which the gallery's ambient climate influences the microenvironment inside cases housing composite archaeological objects.

Conclusion

It is worth noting that the two graphical representations employed in this study, the stacked bar chart and the line graph, present identical quantitative data but from two complementary analytical perspectives. The bar chart highlights the quantitative differences between the materials under study, while the line graph illustrates the direction of change and the relative response of each material to different environmental factors. This dual approach enhances the clarity and scientific interpretability of the results.

The findings derived from both graphical representations indicate that organic materials, specifically wood and leather, exhibit greater sensitivity to environmental factors than metallic materials such as iron. This finding is consistent with the established literature on cultural heritage conservation concerning the susceptibility of organic materials to deterioration resulting from climatic variation within museum environments. Wood is principally composed of cellulose and lignin, both of which are hygroscopic in nature, while leather is composed of proteinaceous fibres (collagen). Both materials possess a pronounced capacity for moisture absorption from the surrounding environment, leading to physical structural changes such as expansion and contraction, which weaken their mechanical integrity and increase their vulnerability to progressive deterioration.

Relative humidity is recognised as one of the most significant factors contributing to the biological deterioration of organic materials within museum environments. Elevated humidity levels create conditions conducive to the growth of micro-organisms such as fungi and bacteria, which feed on the organic components of archaeological materials. The activity of these micro-organisms may lead to the degradation of cellulosic fibres in wood or collagen fibres in leather, resulting in discolouration, structural weakening, and in certain cases the irreversible loss of original material. For this reason, preventive conservation literature consistently emphasises the importance of maintaining stable relative humidity levels within museums, given their decisive role in limiting biological deterioration and preserving the long-term stability of organic materials.

In this context, the regulation of environmental factors, particularly humidity, temperature, and light levels, stands out as one of the most critical strategies in the field of preventive conservation of museum collections. Environmental stability reduces the rate of physical, chemical, and biological reactions that lead to the deterioration of archaeological materials, especially those of an organic nature.

References

Al-Dibbaq, T., & Fawzi, R. (1979). 'Ilm al-Mataḥif [Museology]. Baghdad: University of Baghdad Press.

Bertrand, L. (1903). Histoire de Philippeville (1838–1903) [History of Philippeville (1838–1903)]. Philippeville: Imprimerie J. Azan.

De Bary, M. O., & Tobelem, J. M. (1998). Manuel de Muséographie: Petit Guide à l'Usage des Responsables de Musée [Manual of Museography: A Short Guide for Museum Managers]. Biarritz: Atlantica.

Hayashi-Denis, N., & de Ruijter, M. R. (2010). La Manipulation des Collections dans les Réserves, Guide sur la Protection du Patrimoine Culturel 5 [Handling of Collections in Storage, Cultural Heritage Protection Handbook 5]. Paris: UNESCO.

Magdalena, K., Blanche, É. G., et al. (1999). Agenda du Patrimoine Mondial, Revue Trimestrielle N° 1 [World Heritage Agenda, Quarterly Review No. 1]. Paris: UNESCO.

Mousa, R. M. (2002). Madkhal ila Fann al-Mataḥif [Introduction to Museology] (1st ed.). Cairo: Al-Dar al-Misriyya al-Lubnaniyya.

Qadus, 'I. Z. (n.d.). 'Ilm al-Ḥafa'ir wa-Fann al-Mataḥif [Excavation Science and Museology]. Alexandria: Dar al-Ma'rifah.

Journal of Ecohumanism
2026
Volume: 5, No:1, pp. 227–236
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v5i1.7233

Shibli, M. al-D. (2008). Dalil al-Matḥaf al-Baladiyy Rusicad [Guide to the Rusicade Municipal Museum]. ʻAin Mlila: Dar Al-Huda.

---

[i] Mousa, R. M. *Madkhal ila Fann al-Mataḥif* [Introduction to Museology] (1st ed.). Cairo: Al-Dar al-Misriyya al-Lubnaniyya, 2002, p. 43.

[ii] Qadus, ʻI. Z. *Ibid.*, p. 304.

[iii] Magdalena, K., Blanche, É. G., et al. *Agenda du Patrimoine Mondial* [World Heritage Agenda], Revue Trimestrielle N° 1. Paris: UNESCO, March 1999, p. 39.

[iv] De Bary, M. O., & Tobelem, J. M. *Manuel de Muséographie: Petit Guide à l'Usage des Responsables de Musée* [Manual of Museography: A Short Guide for Museum Managers]. Biarritz: Atlantica, 1998, p. 112.

[v] Hayashi-Denis, N., & de Ruijter, M. R. *La Manipulation des Collections dans les Réserves* [Handling of Collections in Storage], Guide sur la Protection du Patrimoine Culturel 5. Paris: UNESCO, 2010, pp. 43–44.