

# IDENTIFICATION AND CONTROL OF DAMAGING MICRO-ORGANISMS IN MANUSCRIPTS OF CENTRAL TABRIZ LIBRARY, IRAN

***Mozhgan Khalili Zonouz\****

National Academy of Azerbaijan Sciences, Baku, Azerbaijan

*Keywords:* hand-written, micro-organism, biological damage, preventive conservation

## 1. Introduction

Manuscripts are among the valuable heritage of any society, having recorded the thoughts and science of their own era with the passage of time in order to transfer them to later generations [1]. In their composition, the most eloquent script of the time was used and skillfully fashioned with special designs such as illumination when all conditions were met; important points to consider for this aspect were the subject, author, calligraphy and size of the manuscripts.

The efforts made by the author to prepare the paper and use the appropriate instruments to write are a separate topic. However, different scientific, historical, social, cultural, etc. values are hidden in each manuscript. Since they have become a library-based collection, they are regarded as valuable and outstanding heritage. The higher the number of manuscripts in a library the greater the value of the collections housed therein. Thus, when only one of the library books is known as world heritage and is recorded in the world heritage list, it becomes and consequently represents the scientific and cultural credit of that human society, bringing pride and growth for the country.

Considering climate conditions, the mentioned copies and library collection are exposed to biological, physical and chemical damage. In such cases, biological factors, especially micro-organisms, are highly emphasized, since they use book materials as nutrition and produce chemical effects.

In order to identify the micro-organisms present in the Central Tabriz Library, which is neither the first nor second place in the country in terms of number of books, while it is ranked first in terms of its contents and universally-registered works, it is necessary to consider this issue as a scientific research topic, and as a way of preparing conservation methods to protect the materials against damaging micro-organisms. It can thus be implemented as a fundamental science in manuscript archive centers.

Based on the conducted analysis, attempts were made to utilize those scientific capacities which were already available in Iran, based on library, field, and laboratory studies in order to develop and adopt an appropriate plan of conservation science. In this regard, the present study aimed to understand, analyze, and deduce from the collected data and recorded findings and considering it a priority in amending the guidelines.

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\* Corresponding author: [Mozhgan.khalili@parasmoon.com](mailto:Mozhgan.khalili@parasmoon.com)

## 2. Methodology

The present study was conducted based on previous library, field, and laboratory studies. The results of these studies were accordingly analyzed to extract the results, leading to the formulation of necessary guidelines for the optimal conservation of the valuable written works which will then be used at the Central Tabriz Library. Applying and implementing the results arising from this study will also be useful in other libraries and institutions.

## 3. The manuscript collection of Central Tabriz Library

The library contains 3265 manuscripts, as well as 5200 lithographic and movable type documents. They are placed on shelves in a mobile shelving system where no provision is made for the necessary air conditioning and climate control. In addition, some of the books are put in show cases for display purposes.

The manuscript collection in the Tabriz Central Library is one of the most important in Iran. It has several thousands of manuscripts in its storage space and is of great value because the majority of its books belong to the Ilkhanid period (1256-1394). Furthermore, the "*Vaghf Nameh Rab'-e Rashidi*", the Deed of Endowment of the Rab' i-Rashidi, which is still in the hands of the Association of National Works, can be considered one of the most interesting and clearest examples of historical evidence of the Ilkhanid Era and therefore a document of outstanding value.

The *Gospel of the Apostles* (Enjil Rasulan) is regarded as another fascinating work in this collection, which has been carefully preserved for 1200 years and is kept in the same showcase as the Endowment (Figure 1-2). Both of these beautiful works are kept in the library and treated as precious gems. The gospel manuscript is a priceless and outstanding volume and of great value in terms of contents. The gospel is written in Assyrian (Syriac language) using an eastern Assyrian accent and letters.

Given the fact that this volume was written more than a thousand years ago on fish skin and not paper, its value as a historical and cultural artifact, is unquestionable.

The books in Tabriz Central Library have been damaged due to frequent displacements and no restoration steps have been taken to correctly preserve them [1] except for some unprofessional repair work, as well as traditional and non-principled restoration.

Climatic fluctuations are quite frequent in the library, in addition to physical, chemical, and biological factors, due to the evident damage in most books. In addition, ventilation and air circulation in the enclosed space are stagnant and there is a lack of standard shelving. The dust accumulated along the shelves (Figure 3-4) is therefore an ideal hiding place for fungal spores and the growth of micro-organisms which together with the climatic fluctuations, all contribute to speeding up chemical, physical and biological damage.



Figure 1. Storage place of the “Deed of Endowment of Rab’-e Rashidi” and the “Gospel of the Apostles (Enjil Rasulan)” manuscript



Figure 2. Storage place of a) “Endowment of Rab’-e Rashidi” and; b) “Gospel of the Apostles [Enjil Rasulan]” manuscript.



Figure 3. A sample of the book arrangement in the manuscript storage at Tabriz Central Library

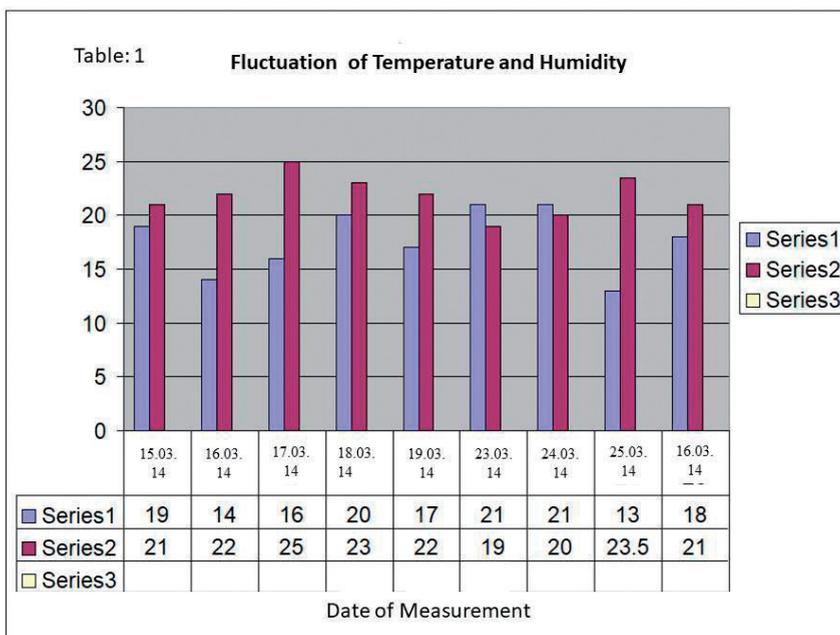


Figure 4. A sample of the book arrangement in the manuscript storage of Tabriz Central Library

#### 4. Climatic fluctuations during field studies

Considering the widespread climatic fluctuations in the library the variations needed to be recorded during the sampling since both factors of humidity and temperature are related to each another and the slightest change in one can affect the other. In addition, a lack of climatic recording means that there is no control over variations in environmental conditions which leads to accelerating the deterioration of the works. Table 1 indicates the climate conditions recorded only during the sampling period.

Table 1. Climate conditions on the recorded days



#### 5. Selection Method of the Studied Samples

In order to identify the microorganisms in the central library, two methods were selected.

A selection of the samples with excellent value (Table 3).

The “*Vaghf Nameh Rab’-e Rashidi*” is among one of the first written works in Iran and registered in the UNESCO Cultural Heritage list.

The “*Enjil Rasulan*” is the oldest book in the library; it is more than 1000 years old and is written in Assyrian (Syriac) (Table 4).

A random selection of 14 samples from the shelves with different titles (Table 5).

## 6. Methodology of fungus identification in Tabriz Central Library

The study is based on several processes as well as laboratory and library research. The main steps are presented in the following seven points.

- Sampling
- Transporting the sample
- Preparing the sample
- Preparing the growth medium
- Inseminating into the growth medium
- Transferring to incubator environment
- Analyzing the results daily for 4-6 weeks

## 7. Why do fungi and other microorganisms cause decay and decomposition of paper objects?

The significant ability of cellulose and collagen in the book structure allows moisture to be absorbed through the atmosphere, which has relatively high humidity, enabling the microbes inside a damp book to grow well and consequently affect the conditions for its correct preservation and storage [2].

The relative humidity of libraries and warehouses for books and paper should be kept constant if possible. Appropriate relative humidity and environmental temperature should be 60% and 15°C (below 18°C, in general) respectively. If the humidity of a library, in which the temperature is 15°C rises from 57% to 63%, each one thousand tons of books can absorb about 10 tons of water vapor [3].

Some microorganisms are able to use the humidity which is released as a result of cellulose decomposition, making decomposition of the cellulose by the fungus rise to 0.55 gram of water for each gram of cellulose; this is the result of fungi feeding on the cellulose itself. Storage and accumulation of water by a fungus colony makes any other type of humidity unnecessary for its survival. As a result, fungus growth occurs inside the book tissue. Humidity therefore plays a major role in the environment which is necessary for fungus growth and survival has a secondary role.

Paper absorbs a large amount of humidity and has non-uniform hairy characteristics. Based on the type and method of producing the fibers in the paper, the quantity and quality of the glues and filling materials, the type and method of production and dehydration, the manner of covering the books and storage, and the temperature and humidity contents of the actual paper, the materials show a varying degree of sensitivity or resistance against attacks from micro-organisms [4]. Fungi prefer acidic environments for their growth and bacteria, a neutral or slightly alkali one. Cellulosic (cellulose decomposing) fungi, bacteria and actinomycetes grow well in paper, in an acidic pH equal to 4 or less, a pH of 6.8-8, and a pH of 5-8, respectively.

Also temperature and relative humidity influence fungi growth. For example, in dry air and dehydration, and cold air, fungi growth stops. The most appropriate conditions for growth are temperatures between 24-30°C and humidity/RH of 65% - 80%. Most bacteria can grow in anaerobic conditions; however, all fungi need oxygen for their growth, even though some fungal spores are able to tolerate low-oxygen conditions for a short time.

The spores of *Penicillium* and *Aspergillus* fungi can tolerate low-oxygen conditions

at least for two weeks, while *Rhizopus*, *Cladosporium*, and *Alternaria* spores lose strength in such conditions. Due to the range of the nutritional spectrum of the fungi, fungal spores are present everywhere, making environmental control a very essential and determining issue. It is generally recommended that library-based materials be kept in conditions of relative humidity between 50% - 55% at a temperature between 16-18°C and suitable ventilation.

More than 350 different fungal species attack books and paper objects, causing some decay and destruction, among which 20 species can also cause fungal and allergic diseases in human beings.

Fungal attack on the book starch and glue leads to their decay. After digesting the starch, the mold attacks celluloid tissues and subsequently rots the paper. However, it is easy to distinguish the rotting impact of the acid and the mold from one another.

Acid renders the paper crisp and fragile, thus the paper, which generally becomes limp after fungal attack, cracks when it is folded while maintaining its soft flexible state. This is due to the moisture content in the paper which keeps the texture of the paper flexible.

In addition, molds alter the paper's ink and iron composition causing the writing to gradually fade away. This makes the manuscripts illegible, destroying their original value once the chemical reaction is complete.

## 8. Paper classification

Paper can be classified based on its resistance to fungi, its resistance depending on the chemical operations employed in the stages of its production.

Machine-made paper from wood paste is more vulnerable than hand-made paper, which is mainly composed of cloth pieces.

Starched paper shows higher resistance against fungi as they absorb less humidity.

Paper, whose pH is from 5.5 - 6 is resistant to molds.

Paper polished with a machine is less resistant against mold due to its softness, cleanness, and humidity-absorption.

Thicker sheets of paper absorb fungal spores. Paper sheets containing gelatin starch or starch by itself, encourage mold growth [5].

Decay, which occurs through biological factors in paper as well as other related factors, is called "biological decay or spoiling". In books, apart from paper, other materials have also been used such as paperboard, leather, cloth, glue or resin, all of which are potential food sources for micro-organisms.

Some papers are made of wood while others are made from cotton and waste paper. However, paper is composed of celluloid materials and the most common factors for the biological decay of paper are bacteria, insects, and fungi, of which bacteria are the least important.

Fungal biodeterioration is considered to be the main threat for paper documents in archives and libraries, since they are apt to decompose celluloid materials. The presence of fungi is visible as spots on the paper, pus or filthiness, with evident signs of decay and frailty [6].

The impact of the fungi is visible as spots of different sizes with irregular round shapes in black, red, purple, brown, yellow, green and without color. The colored spots on different surfaces of natural (plant leaves) or artificial (paintings, paper, etc.) materials are called "mildive plant rust".

Such variations in the color of the spots, as well as their brightness or darkness, depend on various factors such as the composition of the paper, acidity, and the assaulting fungus species, along with the simultaneous presence of other micro-organisms and the duration of their growth [7].



Figure 5. A mold-corrupted book

### 9. Laboratory findings and field-based studies

According to the statistical results given in Table 2, based on field and laboratory assessments, it can be said that 100% of lithographic manuscripts in storage are corrupted with micro-organisms.

Table 2. Results of field and laboratory studies

Fungus species	Number of experimented plates	Percentage of growth results
Aspergillus niger	26	35.5
Aspergillus rhizopus	8	10.9
Aspergillus flavus	1	1.3
Cladosporium	1	1.3
Catheomia	1	1.3
Penicillium	25	34.2
Sum of grown plates	73	

Table 3. Selected sample of Rab'-e Rashidi

Title		Vaghf Nameh Rab –E-Rashidi					Scribe	khajeh sheikh Rashiddadin Fazk Allah								
							Microorganisms.									
Chemical	physical	fiber	parting	bending	binding	paper	cover	fungi	fiber	binding	paper	bending	cover			
Acidate								Niger	*		*					
Chang color				*		*		Rhizopus		*						
Desiccation							*	Flavus								
tear		*				*	*	Penicillium			*		*			
blot					*	*	*	Chaetomium								
Restoration						*		Cladosporium								
grease						*										
moisture					*	*										
abrasion						*	*									
color				*												

	
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Table 4. Selective sample of Enjil rasulan

Table: 4							Microorganism damage in Tabriz Central Library						
Title		Enjil-E- Rasulan					Scribe						
							Microorganisms.						
Chemical	physi cal	fiber	pating	bending	binding	paper	cover	fungi	fiber	binding	paper	bending	cover
Acidate						*		Niger			*		*
Chang color				*		*		Rhizopus					
Desiccation							*	Flavus					
tear		*				*	*	Penicillium			*		
blot		*			*	*		Chaetomium					
Restoration						*		Cladosporium					
grease						*							
moisture					*	*							
abrasion						*	*						
color				*									




Table 5. Randomly-selected sample Khazan and Bahar

Table: 5							Microorganism damages in Tabriz Central Library						
Title		khazan & Bahar					Scribe	Hedayat Karbalaye Abdollah Zonouzi					
I							Microorganisms.						
Chemical	physi cal	fiber	pating	bending	binding	paper	cover	fungi	fiber	binding	paper	bending	cover
Chang color				*		*		Rhizopus					
Desiccation							*	Flavus					
tear		*				*	*	Penicillium			*		*
blot		*		*	*	*		Chaetomium					
Restoration						*		Cladosporium					
grease						*							
moisture					*	*							
abration						*	*						
color				*		*							
													

Table 6. Biological damage in cultivated samples

Fungi sample	Penicillium	Niger	Rhizopus	Chaetomium	Cladosporium	Flavus
Qoran	*		*			
Moemiat –E-Hosein Ebn-E-Mohammad Hoseini	*					
Javaher –E-Ensha	*	*		*		
Leyli Majnun		*	*			
Hedayatol Avam	*	*				
Moayyemat	*	*	*			
Sharhol Ghotr		*				
Sabet	*	*	*			
Kashef-E-Asrar	*					
Resaleyi dar Ahadis	*					
khazan & Bahar	*	*				
Moazi Tabrizi	*	*				*
Vaghf-E-Nameh	*	*	*			
Enjil-E- Rasulan	*	*				
Nasekhol Tavarikh		*				
<b>Estimated percentage of microorganism contamination detected in books.</b>						
Penicillium	Niger	Rhizopus	Chaetomium	Cladosporium	Flavus	
75%	75%	31.25%	6.25%	6.25%	6.25%	

## 10. Presenting control solutions

According to the scientific association of CCI, the easiest, safest and most effective methods of preventing and controlling the fungi and currently-used methods are non-chemical methods [8]. They are employed for organic substances in museums and library collections. Non-chemical methods include prevention, non-chemical control, and taking safety measures when working with affected works. Suitable preventive conservation can stop the growth of microorganisms and preserve the condition of the written works.

Correctness, safety and practicality are the principle technical characteristics to take into account in archive storage, as well as the rooms containing the documents and objects. These three aspects are connected to each other and should therefore be examined as a whole and not separately.

## 11. Location of the archive

Whatever the type and design of the building, the areas mentioned below should never be used for storing archives:

- Unsafe environments, such as damp cellars and attics which get very warm in the summer and very cold in the winter.
- Dangerous environments – in proximity to steam tanks, boilers, etc.
- Problematic environments in terms of accessibility (remoteness from the city, bad roads, etc.)
- Objects and documents should not be placed in places without control or surveillance or where they are easily accessible to any person.
- In the case of archive rooms being separate from other parts of the main building with walls, doors or fireproof floors, the objects and documents should be transferred using trolleys and automatic belts.

## 12. Shelving

Preventive conservation is an appropriate solution to impede or arrest the proliferation of micro-organisms and maintain the originality/integrity of written works in collections and libraries. First, both the environment and the books should undergo a cleaning phase, as well as disinfection (asepsis) and all sources of dust accumulation should be eliminated. Pollutants also need to be identified and removed because they affect the artifacts and manuscripts stored on the shelves and will eventually lead to their deterioration. All manuscripts should be transferred to the archives for correct storage on specifically designed standard shelves. The storage system should also include climate control and appropriate covering and shelving materials.

## 13. Shelf storage

Shelves are the main structures used for storing materials in archives. Their sizes are more or less standard and installation methods are the same in most countries [9].

As shown in Figure 3 a shelf may be mobile or stable. Thus, the following issues should be considered during their selection.

In order to prevent fungus and mold growth, there should be the possibility of air exchange and circulation between the shelf and its surrounding environment, which is done according to precise calculations.

Shelves are preferably made of metal due to the problem of common pests in wood and paper.

In order to avoid any chemical impact, it is necessary to use an appropriate covering. The use of zinc-plated materials with their high-quality powder coating improves the surface and adds to the protection against aggressive substances in the archival items, as well as a providing shelving. The shelving is constructed based on the books' volume, shape and statics.

Nowadays, steel plate is usually the material used for making archive shelves for collections and libraries. Wood was used for shelving for a long time, but today the use

of wood is no longer very common, due to its easy combustion and the danger posed by termites as well as other insects.



Figure 6. Samples of stable and appropriate shelving for the archive of books and written works

#### 14. Acid-free boxes

Generally, acid-free boxes are made of acid-free paperboard which means they are made of paper that has a pH that is neutral or alkaline. 100% bleached cellulose has a pH of 7.5 -10 which is known to be acid free. Such packaging plays an important role, especially for written works, documents, and vulnerable materials.

As shown in Figure 7, these boxes provide suitable conditions for storing documents and books due to their paperboard structure.



Figure 7. Acid-free boxes and packaging

Firstly, they prevent dust accumulation on the surface of manuscripts, breaking any direct connection and consequently, interaction of physical pollutants with the books. Secondly, they resist chemical factors, minimizing the possibility of chemical damage from air pollutants.

## 15. Desirable climate conditions: relative humidity and temperature measurement

Based on the above-mentioned issues, the temperature and humidity where the collections are kept should be frequently measured so that they do not exceed the desired limit. This rule is applied to all geographical areas and all building types. The thermometer should be installed in the building accurately and the temperature should be recorded in various places at different times, since warm and cold air circulate inside the environment according to their lightness and heaviness.

A thermo-hygrometer is a device which measures environmental humidity. The sling thermo-hygrometer is considered the simplest type while the mechanical variety is the most complicated one. As illustrated in Figure 8, an appropriate thermo-hygrograph and thermo-hygrometer can be used to measure the humidity and temperature of the inner pages of the books, simultaneously.



Figure 8. Thermo-hygrometer

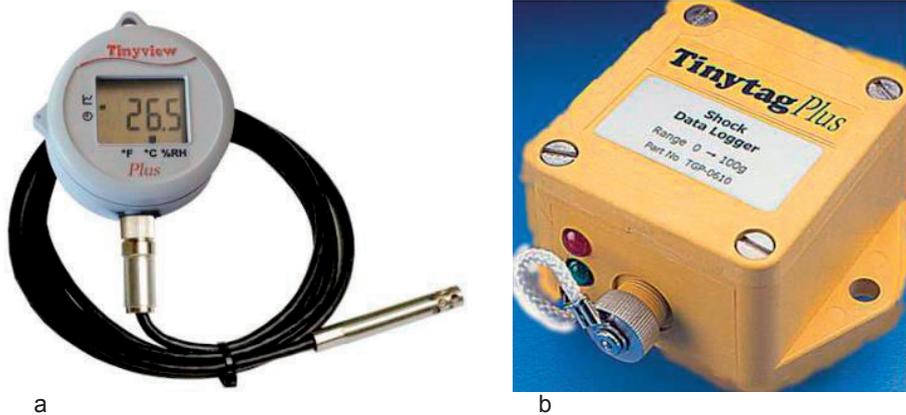


Figure 9. Equipment for mapping temperature and humidity; a) thermo-hygrometer with a probe can be connected to shelves and display cases; b) data-logger to record and archive temperature and humidity changes in the archive.

### References

- [1] Fadayi, Gh. (2007). Acquaintance with Manuscripts and Rare (Persian and Arabic) Works, 1<sup>st</sup> edition, Tehran, SAMT Publications.
- [2] Beniger, D. (2007). Insect Pests in Museums, trans. Farahmand Boroujani, Goldasteh Publication, 1<sup>st</sup> edition.
- [3] Qahri, M. (2006), A Review of Harmful Fungal Factors of Paper, Pathology and Preventive and Confrontation Methods, Restoration and Research Journal, Year 1, No. 1.
- [4] Dawson, J.E., revised by Strang, T.J.K.,) 2000(. Solving Museum Insect Problems: Chemical Control in Technical Bulletin N.15, Canadian Conservation Institute, ISBN 0-662-28311-2, Canada.
- [5] Guilds & MacDonald, M., (2004, Mould Prevention and Collection Recovery: Guidelines for Heritage Collections.
- [6] Evans, E. J. and Richardson, M. D. (2003), Mycology (Practical Methods), trans. Alireza Khosravi, 2nd edition, Academic Center for Education, Culture and Research (Tehran Branch).
- [7] Strang, J.K.T. and Dawson, J. E., (1991). Controlling Museum Fungal Problems in Technical Bulletin N.12, Canadian Conservation Institute, ISBN 0-662-54950-3, Canada.
- [8] Niknam, M. (1992), Pests and Damages of Library Materials, Secretariat of Board of Trustees of General Libraries of the Country.
- [9] Zanooz, K. H., (2006). Storage and Archive Solution, Parasmoon Publication

## Biographical notes

**Mozghan Khalili Zonouz** is a PHD candidate at Azerbaijan National Academy of Sciences. She is also a lecturer in the IAU south branch of Tehran. She has presented a number of articles in international conferences on restoration as well as at the 2<sup>nd</sup> international conference in Tbilisi, Georgia, on International Biodeterioration & Biodegradation in Tehran. She has also carried out research projects in historical books, documents and methods relating to conservation. She has experience in the conservation and restoration work of artifacts and books in Golestan Palace and Malek Museum and Library.

## Summary

A large number of historical artifacts have low resistance to pests since they are made of organic substances. Such works can be consumed by several living organisms and can often be an ideal environment for micro-organisms to grow, particularly when favorable conditions such as appropriate climate and absence of light are present.

The way in which manuscripts are stored in archives, such as shelves, acid-free boxes and relative temperature control, means that both humidity and aerosols can play a determining role in their safety. Considering the principle of the priority of conservation over restoration, several measures should be adopted for the safety and authenticity of the works, which will also lead to a decrease in restoration costs.

The Central Tabriz Library possesses a precious collection consisting of several thousand volumes of valuable books, authentic documents and lithographic books. It is worth noting that the first hand-written work from Iran to be registered on the UNESCO Memory of the World Heritage list was, "*Vaghf Nameh Rab'-e Rashidi*", the Deed of Endowment of the Rab' i-Rashidi. The document is a historical manuscript book authored by Sheikh Rashid al-din Fazlollah and is regarded as a part of this collection.

## Riassunto

Un gran numero di beni culturali sono vulnerabili ai parassiti poiché sono costituiti da sostanze organiche. Tali beni possono essere deteriorati da diversi organismi viventi e spesso possono, loro stessi, essere un ambiente ideale per la crescita dei microrganismi. In particolare quando sono presenti condizioni climatiche favorevoli e assenza di luce.

La modalità di conservazione dei manoscritti svolge un ruolo determinante per la loro tutela. Considerando il principio della priorità della conservazione rispetto al restauro, dovrebbero essere adottate diverse misure preventive, che porterebbero anche a una diminuzione dei costi di restauro.

La Biblioteca centrale di Tabriz possiede una preziosa collezione composta da diverse migliaia di volumi pregiati, documenti autentici e libri litografici. La biblioteca conserva il primo documento scritto in Iran: il "*Vaghf Nameh Rab'-e Rashidi*, Deed of Endowment of the Rab' i-Rashidi". Il manoscritto di cui è autore Sheikh Rashid al-din Fazlollah è inserito nella lista del patrimonio dell'umanità UNESCO.