

Chapter 16

DISINFECTION OF PAPER MATERIALS IN BRAZIL

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16.1. INTRODUCTION

There are a variety of ways in which paper materials can become contaminated by fungi, ranging from intrinsic causes, such as contamination during the manufacturing process, to extrinsic causes, such as contact with airborne conidia and contamination through contact with contaminated surfaces. The use of aqueous substances and organic adhesives in conservation treatments can also result in contamination.

Airborne fungi and bacteria are always present. Tropical countries with high temperatures and high humidity provide an ideal environment for the proliferation of these microorganisms. In Brazil, *Aspergillus*, *Cladosporium*, *Epicoccum*, *Fusarium* and *Penicillium* are prevalent in the environments of archives and libraries [16.1]. It is important to note that various factors influence conidia growth on cultural items, including the substrate, the different types of surface and the quality of air circulation [16.2]. The risk of biological activity is related to the inherent moisture level of the material as well as the temperature, humidity and air exchange rates in the storage environment for a collection [16.3].

A lack of financial resources for preventive conservation can leave cultural institutions vulnerable. Many institutions have air-conditioning systems to control the temperature in storage areas, but if the equipment develops faults that are not corrected, this can cause damage to the collection due to humidity and high temperatures, leading to widespread contamination. Fungal and bacterial contamination can also present health hazards to humans.

The presence of fungi on books and documents will result in the hydrolysis of cellulose owing to the presence of chemicals produced by their metabolic processes. These chemicals, which use cellulose as a source of nutrients, may affect the integrity of the paper [16.4].

Cultural heritage institutions are dedicated to preserving artefacts and preventing their degradation. Chemicals were used to protect the physical integrity of objects in many collections. Fumigating agents such as ethylene

oxide, formaldehyde, carbon tetrachloride and other compounds were a suggested treatment in the 1970s [16.5]. As a result of the prohibition of many of these chemicals, owing to their carcinogenic properties and high level of environmental toxicity, conservators sought less invasive treatments. Gamma irradiation emerged as an important alternative to the use of chemicals, and many case studies have demonstrated the safety of using radiation for disinfection [16.6].

16.2. CASE STUDIES

16.2.1. Example 1: Disinfection of the Mário de Andrade Library

The Mário de Andrade Library, situated in the city centre of São Paulo, was the first, and is now the primary, public library in the city. Established in 1925, it originated from the collection of the city council and has evolved over time to be one of the most significant cultural institutions in Brazil. With a rich history, the library has solidified its importance and now provides access to more than seven million documents, including books, journals, maps, photographs and various other materials, making it a vital resource for research and cultural exploration [16.7].

In 2012–2014, the Mário de Andrade Library faced repeated problems with fungal infestation on all of its 22 floors of books and other materials — affecting approximately 10% of the total collection, including the rare books section, owing to a malfunctioning air-conditioning system that caused the relative humidity to reach levels that were unsuitable for preserving bibliographic materials [16.8, 16.9]. Approximately 18 000 volumes and other items were packed in appropriate boxes and transported for disinfection at the Multipurpose Gamma Irradiation Facility at IPEN.

16.2.1.1. Preparation of the treatment

In 2013, the company that was selected to manage the restoration started to make use of the Multipurpose Gamma Irradiation Facility at IPEN, with the books undergoing a thorough treatment process. Taking into account scientific research on the resistance of paper to radiation [16.8, 16.10–16.13], during the treatment the books were exposed to a radiation dose of 10 kGy, which effectively eliminated the presence of insects and fungi, preserving and safeguarding the integrity of the books [16.14].

16.2.1.2. Microbiological analysis

Identification of the fungal species is recommended when there is a health-related concern [16.2]. Therefore, analyses were carried out to identify *Penicillium* on the affected books. After the irradiation, the fungus was no longer found on the books (Fig. 16.1). The results obtained from the microbiological analysis showed that an absorbed dose of 6 kGy was enough to eliminate most of the typical fungi affecting cellulose based materials (e.g. *Penicillium*, *Aspergillus*, etc.).

After processing by ionizing radiation, all of the books were cleaned and returned to the shelves (Fig. 16.2).



FIG. 16.1. Microbiological analysis results: (a) before treatment, (b) after dry cleaning and (c) after gamma irradiation.



FIG. 16.2. Books before and after irradiation.

16.2.2. Example 2: Rare book collections preserved by ionizing radiation

Collections of rare books often include unique items of historical, cultural and aesthetic significance. Preserving these collections requires measures that minimize interventions and keep the works as original as possible.

Any treatment applied to such collections must be guided by the ethical principles of conservation and restoration. In Brazil, rare books from both public and private libraries have been subjected to gamma radiation at IPEN for disinfection. This method ensures the preservation of these valuable works while adhering to ethical conservation standards. A description of the irradiation facility and the treatment can be found in Chapter 15.2.

16.2.2.1. Incunables treated by gamma radiation

A private library in Brazil has a distinctive collection of incunabula (books printed in Europe before 1501), with a unique focus on publications related to wine (Fig. 16.3). This library, which comprises approximately 5000 volumes, faced challenges that included insect infestation and mould growth. Traditional control treatments proved ineffective against the fungi, hence radiation treatment was selected for the collection [16.15] owing to the rarity of the incunabula and the need for effective conservation measures.

Prior to the irradiation process, a meticulous examination and classification of the materials was undertaken, and items were appropriately packed in boxes according to the degree of biological contamination. The collection underwent gamma irradiation treatment at IPEN, with 2 and 10 kGy doses applied for insects and fungi, respectively. Additional services, including cleaning, were carried out by a commercial book restoration company.

Notably, many of the rare books contained wooden parts. A radiation dose of 2 kGy was applied to address potential contamination from insect larvae, as a dose of 1 kGy proved insufficient (Fig. 16.4). This comprehensive treatment approach aimed to safeguard the longevity and integrity of these valuable and unique publications.

16.2.3. Example 3: Cervantina Collection

The Cervantina Collection of the University of São Paulo is a remarkable collection of illustrated editions of Miguel de Cervantes's *Don Quixote* (Fig. 16.5). Comprising more than 700 volumes in 60 different languages, the collection features rare and unique editions, showcasing illustrations by renowned designers such as Gustave Doré, Salvador Dalí, Francisco Goya and Candido Portinari. The illustrations, employing diverse techniques, such as woodcuts, etchings,

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FIG. 16.3. Incunabula collection.



FIG. 16.4. Incunabula treated with gamma radiation.



FIG. 16.5. Illustrated books of the Cervantina Collection (courtesy of the Nuclear and Energy Research Institute).

watercolours, ink and lithography, reflect the distinctive styles of each artist and were created in different periods.

Donated to the university in 2011, the collection underwent an initial diagnosis that revealed contamination by insects and fungi. To address the issue comprehensively, all of the books were subjected to treatment with gamma radiation at IPEN (Fig. 16.6). Subsequently, they were incorporated into the Rare Books and Special Collections Library of the University of São Paulo. The radiation treatment and meticulous preservation work ensured the long term integrity and accessibility of this valuable literary and artistic heritage.



FIG. 16.6. Books of the Cervantina Collection after irradiation and cleaning.

16.3. CONCLUSIONS

Infestations, particularly in enclosed environments such as libraries, demand urgent attention in order to prevent substantial damage to a collection. Gamma irradiation is an effective and safe method that ensures the integrity of the treated books.

Irradiation to disinfect rare books and special collections is effective in eradicating contamination by insects and fungi. It ensures the comprehensive elimination of microorganisms and is a safe way to treat books without posing health risks to humans. This approach not only addresses the urgency of responding to infestations but also safeguards the long term preservation of valuable literary and cultural artefacts. However, while ionizing radiation is a viable, non-toxic treatment, the need for ongoing preventive conservation measures must be continually monitored after the treatment.

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