

Chapter 15

MASS DECONTAMINATION AND OVERSIZED OBJECT TREATMENTS USING GAMMA RADIATION PROCESSING IN BRAZIL

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15.1. INTRODUCTION

Biodeterioration of cultural heritage objects can occur as a result of accidents (e.g. floods and water ingress) and infestations when artefacts are poorly stored [15.1, 15.2]. If a collection becomes contaminated, an immediate response from the institution responsible for the collection is necessary, since pests and mould develop quickly, potentially destroying the collection [15.3]. In Brazil, the humid tropical climate across most regions provides an environment that is conducive for the development of fungi and insect infestations, resulting in many such attacks on collections.

The presence of particulate material in collections contributes to the development of insect infestations and fungi. Different environments as well as human and natural activities can affect the composition of such materials. Archives, libraries and museum exhibits often contain dust, which can include airborne particles such as particles of soil and other minerals, soot, skin cells, fragments of textiles, fungal conidia and spores, pollen, plant matter and other substances, which provide a source of nutrients for insects and fungi, thereby creating the ideal environment for infestations and contamination of cultural items [15.4, 15.5].

In recent decades, the use of ionizing radiation has emerged as a valuable alternative for mass decontamination in Brazil. Specifically, IPEN has played a pivotal role in establishing this technology as a method to treat collections.

The application of ionizing radiation to cultural heritage objects has been studied since the 1950s [15.6]. Unlike other disinfection treatments, gamma rays do not leave a residue on the treated materials, which is an advantage, since items can be handled safely immediately after irradiation. With its high frequency and high energy, ionizing radiation is deeply penetrating, which allows large volumes of a material to be treated. A reliable dosimetry system can calculate and certify

the biocidal effects of ionizing radiation, making it a safe and controlled method of eliminating insects and microorganisms. According to some authors [15.7, 15.8], gamma radiation can affect the mechanical properties of cellulose, but the damage caused by insect infestations and fungal growth can be greater, and hence this technique is recommended for disinfecting cultural heritage objects.

In this chapter, successful cases of mass treatments utilizing ionizing radiation are presented. These cases highlight instances where the technology has achieved the total recovery of materials affected by contamination, showcasing its efficacy in preserving and restoring valuable cultural and historical artefacts.

15.2. PREPARATION OF THE TREATMENT

The Multipurpose Gamma Irradiation Facility at IPEN is categorized as a level IV facility (panoramic wet source storage irradiator) according to Ref. [15.9]. Within this compact irradiator (12 m³), the radioactive source is securely stored and shielded within a 7 m deep pool of deionized water when not in operation [15.10]. The ⁶⁰Co source pencils, measuring 45 cm in length and 1 cm in diameter, are encased in corrosion resistant stainless steel, allowing gamma radiation to be emitted while preventing any radioactive material from escaping, thus mitigating contamination risks. The 48 source pencils are strategically positioned within source modules and distributed across the racks, enabling precise source geometry. The racks function as structures housing the source pencils and facilitate their movement from the pool bottom to the irradiation chamber. Access to the radiation room is restricted during operation via an entry control system [15.11].

More than 1000 m³ of several book collections attacked by insects and fungi have been disinfected by irradiation at IPEN (Fig. 15.1).



FIG. 15.1. Large scale irradiations of archived materials at the Multipurpose Gamma Irradiation Facility, Nuclear and Energy Research Institute.

The dose of absorbed radiation to be applied is determined on the basis of the biological contamination of the materials. For xylophagous insects and materials containing cellulose, an absorbed radiation dose of approximately 1 kGy is applied. For fungal contamination, an absorbed dose of 6–10 kGy is delivered [15.12, 15.13]. Upon completion of the processing, the material is returned to the conservator for cleaning and other curative restoration actions.

15.3. CASE STUDIES

15.3.1. Example 1: Architectural drawings from the School of Architecture and Urbanism of the University of São Paulo

Inadequate storage conditions, marked by fluctuations in temperature and humidity, resulted in an infestation of insects and fungi within the collection of architectural drawings at the School of Architecture and Urbanism of the University of São Paulo. Faced with the extensive biodeterioration of a vast array of materials, the institution opted for a large scale treatment using ionizing radiation. At the Multipurpose Gamma Irradiation Facility at IPEN, more than 2000 original architectural drawings and associated materials underwent thorough disinfection, effectively mitigating the effects of insect and fungal contamination (Fig. 15.2).

15.3.2. Example 2: Cia City

Founded more than 100 years ago as City of São Paulo Improvements and Freehold Land Company Limited, and now known simply as Cia City, this private commercial institution remains active, selling land in the city of São Paulo [15.14]. Cia City is a pioneering company in the area of urban development. It was created in 1911 by French, English and Brazilian investors and was important to the history and landscape of São Paulo throughout the twentieth century.

The Historical Collection of Cia City consists of documents that are part of the institution's history, such as dossiers of all sales made, with the history of each buyer and their acquisition, plans, projects (from conception to final product), advertisements and advertising records, in addition to corporate, accounting and financial documents. In 2015, the company opted to store its collection in professional specialist storage, and for this purpose it commenced the disinfection of all documents with ionizing radiation. The whole process took about six months, as there was a large number of boxes. More than 200 m³ of material was processed by gamma radiation at IPEN (Fig. 15.3).

Several documents had been damaged by flooding prior to being transferred to the new storage facility. Ionizing radiation was applied to the parts of the collection that had been in contact with the water to eliminate the possibility of bacterial contamination.

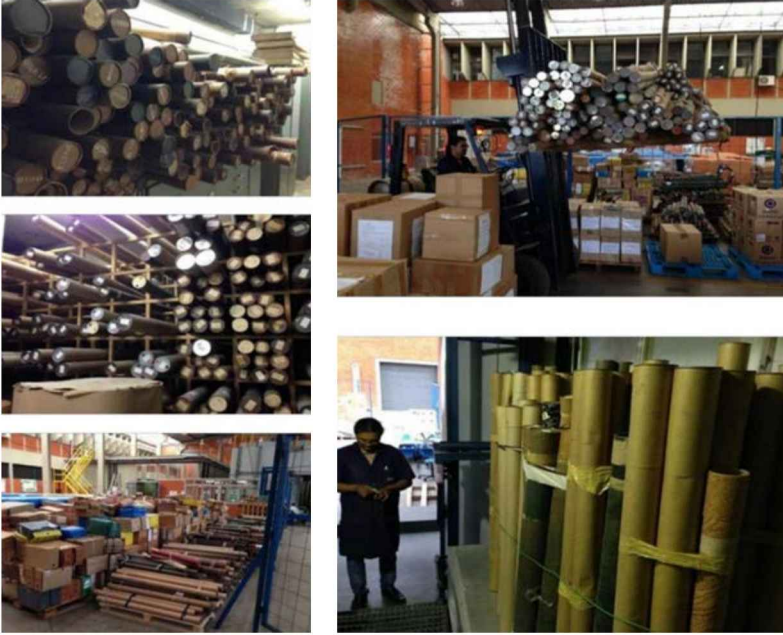


FIG. 15.2. Architectural drawings from the School of Architecture and Urbanism of the University of São Paulo treated at the Nuclear and Energy Research Institute.



FIG. 15.3. Cia City historical documents at the Nuclear and Energy Research Institute.

15.3.3. Example 3: Library of Chemistry and Pharmacy, Institute of Chemistry, University of São Paulo

In 2019, part of the library's collection, approximately 12 000 volumes and 3000 journal issues, required an immediate emergency intervention owing to an infestation of *Anobiidae* at all stages of development (eggs, larvae, pupae and adults). Infestations of this insect are typically found in cool, humid places with poor air circulation. *Anobiidae* do not develop in areas with air humidity levels below 55% [15.15].

In view of the mass infestation of the collection, the need for an emergency intervention to stabilize and repair the damage as well as concern over the collection's preservation, the library requested IPEN to treat the collection with gamma radiation. Owing to the considerable quantity to be processed, a schedule was established giving priority to the most critical batches. The work was divided into progressive stages in which 4 m³ of material per week was treated (Fig. 15.4).

In general, *Anobiidae* larvae prefer to attack old, dusty books. For this reason, cleaning all items after gamma radiation treatment is essential to prevent future infestations.

15.3.4. Example 4: Disinfection of large artworks

The conservation of large format artworks affected by insects or fungi is a challenge for restorers owing to their size and shape, and traditional decontamination treatments are often not feasible for them.

Because of the low predictability of gas penetration and the need to maintain strict control over the process in order to ensure its effectiveness, treatments using large volumes of modified atmospheric gases may not be effective [15.16]. However, ionizing radiation can be an effective method for the disinfection of large objects.



FIG. 15.4. Cleaning books after gamma radiation treatment.



FIG. 15.5. Positioning the box inside the irradiation chamber was difficult owing to the weight of the object.

An Indigenous Peoples object that was affected by subterranean termites was treated by the Museum of Archaeology and Ethnology of the University of São Paulo in 2023. The object, a cylinder made from buriti palm leaves and stalks of the caeté palm tree, is typically made by men from the Indigenous Bororo people in the Mato Grosso state of Brazil and plays an important role in funerary rituals. Its width can exceed 2.80 m, and it is very dense and very heavy. For objects such as these, tailored transport arrangements are required so that they can be transported safely and in accordance with the museum's conservation protocols (Fig. 15.5).

Such artefacts can benefit from the use of ionizing radiation because gamma radiation can treat an object in a single application. Gamma rays have high penetrating power, and their application ensures dose homogeneity throughout the structure (Fig. 15.6).

To ensure the success of a treatment, it is essential that an oversized object receives the dose evenly [15.17]. At the Multipurpose Gamma Irradiation Facility, radiation processing can take place in stages on either side of the source rack, and dosimeters are positioned at different points of the object's geometry.

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FIG. 15.6. Modern art radiation processing at the Nuclear and Energy Research Institute.

It is necessary to reposition dosimeters after intermediate readings to measure the final dose. Measurements are carried out using an ultraviolet–visible spectrophotometer at the end of the radiation processing to ensure that the recommended dose has been applied, taking into consideration the uncertainties in the measurement of between 2% and 2.5%.

15.3.4.1. Pinacoteca de São Paulo

The Pinacoteca de São Paulo, established in 1905, is a museum of visual arts with a focus on Brazilian art from the nineteenth century to the present day. As the city's oldest art museum, it has amassed a remarkable collection, boasting nearly 11 000 works of art and receiving approximately 800 000 visitors each year.

The Multipurpose Gamma Irradiation Facility at IPEN is one of a few facilities that can carry out radiation treatments on oversized objects. An example of such an oversized object is a sculpture by José Bento, prominently displayed in the Jardim da Luz in São Paulo, next to the Pinacoteca de São Paulo, which was contaminated with termites and fungi. Owing to its substantial size and weight, approximately 1 tonne, the sculpture underwent gamma ray treatment at IPEN.

A polymethyl methacrylate dosimetry system, with calibration traceable by the International Dose Assurance Service of the IAEA, was fixed at strategic points on the artwork's box (Fig. 15.7). Following the radiation processing, the sculpture was sent for restoration to ensure its continued accessibility by the public.

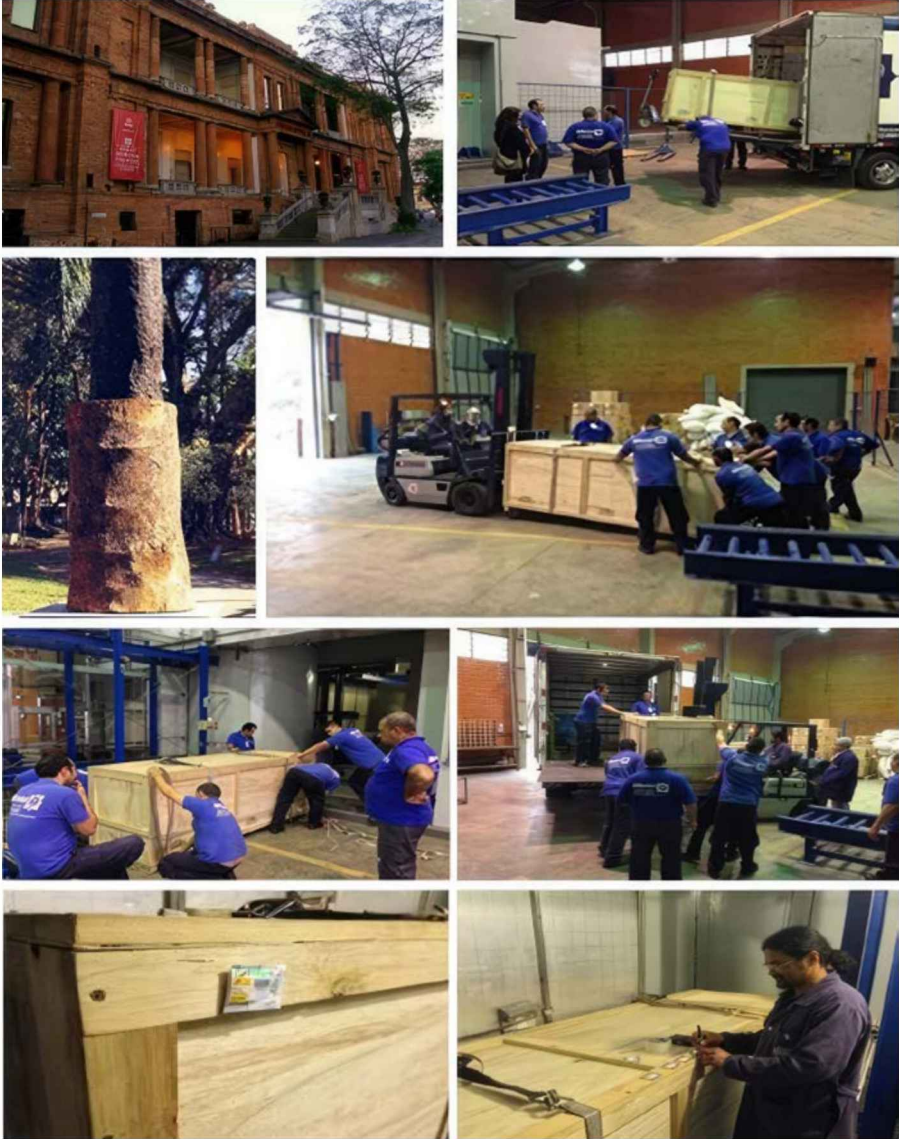


FIG. 15.7. Receipt of the sculpture at the Nuclear and Energy Research Institute and dosimeter placement.

15.3.4.2. Conservare Studio

Conservare Studio is a company that provides conservation and restoration services for artworks in private, museum and business collections.

After receiving an oil painting on canvas for restoration, an initial conservation report identified a fungal attack on the artwork. Decontamination with gamma rays was conducted at IPEN by applying a dose in the range 6–10 kGy. The 3.5 m × 4.5 m canvas painting was disassembled from its frame, packed and rolled up so that it could enter the irradiation chamber (Fig. 15.8).

15.3.4.3. Ivani and Jorge Yunes Collection

The Ivani and Jorge Yunes Collection is a private collection of artworks covering 23 centuries of global art history. The collection features artefacts representative of Europe, Latin America, Africa and Asia.

The collection's preservation programme includes gamma radiation treatment for the decontamination of artefacts affected by fungi, woodboring insects and termites. Since 2018, through a partnership with IPEN, more than 30 artworks have been treated (Fig. 15.9).

A selection of the historical and archaeological objects of the collection have been donated to public institutions, including museums of the University of São Paulo. Before these objects were transferred to the museums, they were treated at



FIG. 15.8. To ensure that the oversized canvas is handled properly, conservators monitor the arrival of an artwork at the Nuclear and Energy Research Institute.



FIG. 15.9. Irradiation of large artefacts from the Ivani and Jorge Yunes Collection at the Nuclear and Energy Research Institute.

IPEN. Objects contaminated by insects were treated with 3 kGy absorbed doses, while objects contaminated by fungi received 6–10 kGy absorbed doses.

Historical objects from the Ivani and Jorge Yunes Collection, such as antique furniture, are currently on display at the Museu Paulista, and, after a thorough cleaning and restoration process, archaeological objects will be put on display in a new visitable storage area at the Museum of Archaeology and Ethnology of the University of São Paulo.

15.4. CONCLUSIONS

The use of ionizing radiation as a treatment method for the disinfection and preservation of collections offers several advantages over conventional disinfection methods. While ionizing radiation presents a promising solution, its relatively recent introduction to the field of cultural material conservation, especially among Latin American cultural institutions, has led to hesitancy among professionals in the field. To address this, there is a crucial need to expand the

dissemination of research findings and treatment results, address concerns and foster confidence in the efficacy and safety of irradiation as a treatment method.

The application of ionizing radiation in preserving culturally valuable materials must adhere to fundamental principles, including justification, optimization and limitation of absorbed dose. This approach aligns with ethical principles in the conservation of cultural heritage, including maintaining objects as closely as possible in their original condition over time.

IPEN has had several partnerships with private and public institutions, such as museums, art galleries, private collections and art restorers, that send contaminated artworks to be treated by gamma irradiation.

The successful irradiation disinfections of large cultural heritage objects that have been carried out demonstrate the feasibility and effectiveness of this treatment. It is important to carry out dose mapping at the radiation facility to ensure the homogeneity of the absorbed dose, especially for large objects.

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