ICOM-CC València 2023
20th Triennial Conference

OBJECTS FROM INDIGENOUS AND WORLD CULTURES

Moving toward sustainable conservation: Experience of the Museum of Archeology and Ethnology (MAE-USP)

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Keywords

ethnographic museums, conservation practices, pesticides, pest control, gamma radiation, ionizing radiation

Abstract

For decades, ethnographic museums treated the organic objects in their collections with pesticides, including DDT, pentachlorophenol, hexachlorobenzene, and paradichlorobenzene. However, by the late 20th century, the use of pesticides in museums was limited, as certain toxic substances were banned for environmental reasons and due to the risks posed to human health. Currently, the Museum of Archeology and Ethnology (MAE-USP) in São Paulo (Brazil) is treating objects affected by insect infestations using ionizing radiation. In this work, we discuss the decisions that motivated the choice of this method as well as the important partnership with the Institute of Energy and Nuclear Research as a major contributor to sustaining the MAE-USP's collections.

INTRODUCTION

The preservation of organic objects, composed of plant fibers, wood, skins, feathers, seeds, and various materials, in museums has always been challenging, as they are prone to deterioration by biological agents. Beginning in the 19th century, collectors and museum professionals around the world made use of chemical treatments, many of which involved toxic substances, in an attempt to ensure the preservation of their collections. Since its founding, the Museum of Archaeology and Ethnology of the University of São Paulo (MAE-USP) has made great efforts to guarantee the conservation of cultural heritage. However, although well-intentioned, pesticide application threatened the health and safety of those applying the treatments and anyone who would handle these objects in the future. In 2010, the MAE-USP abolished the use of pesticides and gradually developed a protocol to reduce the risks of infestations. Among the preventive conservation actions included in the protocol is the use of ionizing radiation. This process is safe and has proven to be a successful alternative to traditional disinfestation methods.

This paper explores the actions carried out by the MAE-USP in partnership with the Institute for Nuclear and Energetic Research (IPEN) to facilitate the treatment of ethnographic objects using ionizing radiation. It also demonstrates the importance of this collaboration in making the conservation process at the MAE more sustainable.

HISTORICAL BACKGROUND

The MAE-USP is located in the city of São Paulo, Brazil. It was founded in 1989, but its history begins in the 1960s, when the Museum of Art and Archeology was created. The collection was initiated in 1964, through an exchange between museums and Italian institutions (Paula 1965, 17). In 1972, the museum was renamed the Museu de Arqueologia e Etnologia (Museum of Archeology and Ethnology). Its collections consisted of pre-Columbian and Brazilian archeological objects as well as African and Afro-Brazilian ethnographic objects, thus expanding the initial goals of the forerunner institution. In 1989, the MAE additionally gathered archeological and ethnographic collections dispersed around the university, including the archeological collections of the Prehistory Institute, archeological and ethnographic objects from the Paulista Museum (MP-USP), and the Plínio

Ayrosa ethnographic collection from the Anthropology Department of the School of Philosophy, Literature and Human Sciences.

While the MAE-USP has been in existence for only a few years, its objects reflect the traditional approach to scientific collectionism that gave rise to encyclopedic museums in the 19th century. As a result, its ethnographic collections are true repositories of the material expressions of Brazilian Indigenous cultures dating from this period and earlier. At the time of the museum's founding, the preservation of these objects was considered both crucial and urgent since it was believed that Indigenous peoples would soon succumb to or be absorbed by non-Indigenous society (Grupioni 1998, Abreu 2005).

TRADITIONAL MUSEUMS, TRADITIONAL PRACTICES

At the very beginning of the 20th century, Hermann von Ihering (1850–1930), the first director of the MP-USP, had already recorded the problems associated with the conservation of organic objects, such as dust, moths, and the high cost of acquiring protective cabinets, in an article that appeared in the first *Journal of the Paulista Museum*, published in 1895 (Ihering 1895, 21). In Brazil, the vulnerability of organic objects stored in museums is exacerbated by the country's tropical environment, where temperatures above 25°C along with the damp conditions encourage insect breeding. Subsequent issues of the same publication thus offered information on methods aimed at conserving collections, including direct applications of kerosene (Ihering 1897, 413–414) and fumigations with hydrocyanic acid gas and potassium cyanurate (Hempel 1898, 56–60). The diverse measures were intended to prevent the scientific, cultural, aesthetic, financial, and other losses that would have been incurred by the failure to protect the collections.

In the late 19th century, several museums, libraries, and archives opted to treat their collections with pesticides, heavy metal compounds, and other substances (Odegaard and Sadongei 2005, 11). The traditional recipes followed by collectors and ethnographic museums to ensure their collection's preservation included the use of inorganic compounds such as arsenic, mercuric chloride, and lead arsenate. However, because the chemical treatment of museum objects, including those now housed at the MAE-USP, was considered routine, it was performed without systematic rigor such that few written records of the methods remain. Thus, in an effort to retrieve historical information on the use of pesticide treatments in MAE-USP, we examined museum accession records, old reports from the Conservation Section, as well as several publications (Froner 1997; Hirata 1997; Revista de Antropologia 1987–1989; Froner et al. 1998; Braga 2003, 121–123). These efforts were complemented by the testimony of former employees and of older staff members who still work at MAE-USP. The most common pests that threatened the collection were cigarette beetles, odd beetles, and clothes moths.

Figure 1 shows a possible chronology of the contamination of the MAE-USP's collections. Additional information was obtained using X-ray fluorescence analyses of some objects from the collections (Vieira and Appoloni 2012).

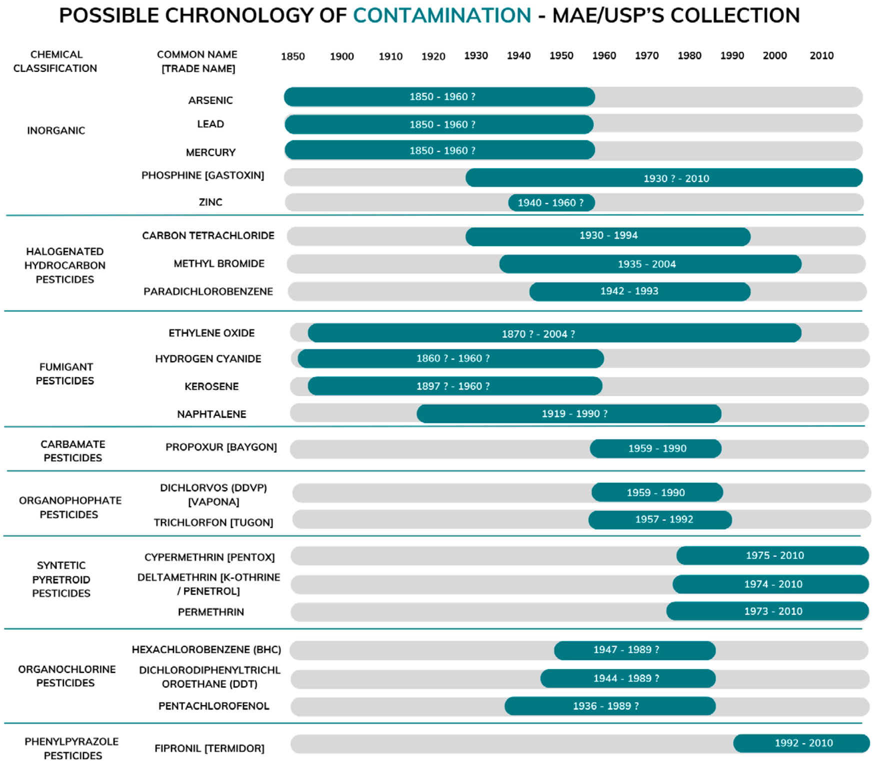

Figure 1. Possible chronology of contamination of the MAE/USP's collection

Figure 2. Indigenous bench (RG 7235), collected in 1950, with evidence of white crystals

Treatments before 1989 were applied either by the institutions of origin or by collectors before the objects were transferred to the MAE-USP.

At the MAE-USP, the use of fumigant agents and synthetic pyrethroids were the main methods used for pest control. In the mid-1990s, a pressurized fumigation chamber was built at the museum (Hirata 1997, Gedley 2003), and a freezer and an anoxia system that uses inert gas were also purchased. However, in the 2000s, access to pesticides became difficult, as the toxic compounds could no longer be legally sold. This led to a shift away from chemical treatment practices, such that in 2010 the MAE-USP conducted its last treatment using phosphine in the fumigation chamber. In 2014, the museum acquired an anoxic atmosphere disinfestation chamber for treating objects using nitrogen and, in 2018, the first objects were treated with ionizing radiation, in tests conducted at the IPEN.

The legacy of old treatments

Synthetic compounds able to repel and eliminate insects became popular after WWII (Stapleton 2005, Conis 2022). By the 1940s, products such as DDT had gained wide acceptance, including by museums (Tello 2021). Over time, with repeated treatments, not just one active substance or chemical agent, but sometimes a whole cocktail was used. The faded colors, residues of white crystalline efflorescence, the breakdown of fibers, corroded composite objects, and indelible stains are the remaining evidence of the possible use of chemicals and fumigants (Figure 2). Residues of pesticides can also be traced through the senses. During routine conservation assessments in the storage area of the MAE-USP, the strong odor of mothballs emerged from opened drawers and when handling some objects. On the other hand, some artifacts that are over a hundred years old are suspect, as they seem to be immune to the action of time. The previous use of toxic chemical treatments was further supported by interviews with former museum employees, who described side effects such as allergies, headaches, and other health problems that they linked to handling the treated objects. A few remaining albeit unclear labels are also indicative of past chemical treatments, but the hazards to which the museum staff were exposed could not be determined from them.

The current trend to involve native communities in curatorial actions in museums has changed the way these institutions work. In recent years, the MAE-USP has intensified its activities involving Indigenous groups. Today, toxic treatments of funerary and sacred objects, human remains, etc., housed in museums are recognized as having been inappropriate. The possession and use of these objects transcend the museum boundaries and must be considered when looking ahead. More than poisoning those who handle them, these contaminated objects limit the actions of museum staff and stakeholders, since chemically treated sacred and culturally sensitive objects cannot be touched, remembered, or renewed by the descendants of their creators. These limitations can threaten the building of trusting relationships between museum staff and Indigenous groups.

NEW, COLLABORATIVE TECHNOLOGIES AIMED AT A MORE SUSTAINABLE FUTURE

The theoretical parameters of the conservation discipline have undergone a revision to include not only remedial conservation but also damage prevention. The need to develop more sustainable approaches to both has led institutions to develop policies that respect the environment and the individuals interacting with the treated objects. This new strategy inspired the MAE-USP to seek alternative, non-toxic treatments for its collections, since controlled environments and preventive measures may not suffice to prevent or limit infestations. In 2018, the museum therefore began a partnership with the IPEN aimed at developing the use of ionizing radiation to treat its collections at risk of biological infestations.

The IPEN is located on the USP's campus and plays important roles in various sectors of Brazilian nuclear science. In 2004, it introduced a cobalt-60 (^{60}Co) multipurpose irradiator (Figure 3), a technology that is entirely Brazilian. Other pioneering actions of the IPEN include helping

Figure 3. The cobalt-60 multipurpose gamma irradiator facility (IPEN-CNEN/SP)

museums, archives, libraries, and other cultural institutions to treat more than 50,000 cultural artifacts affected by insects and mold, through the use of ionizing radiation.

How does it work?

The ionizing radiation utilized in industrial processes consists of electromagnetic waves, such as gamma and X-rays, or charged particles, such as accelerated electrons (IAEA 2017, 43). Gamma rays can be used to sterilize materials and for the disinfection of cultural heritage. The energy source used in the IPEN's multipurpose irradiator is ^{60}Co, which has several advantages in terms of its reliability, efficiency, and environmental safety.

The facility has a panoramic, wet source storage compact irradiator of 12 m³, in which the radioactive source is stored and fully shielded in a seven-meter-deep pool of deionized water. The facility uses ^{60}Co source pencils, in which the radioactive material is encapsulated in corrosion-resistant stainless steel. Racks house all the source pencils, enabling the source system's movement from the bottom of the pool to the irradiation level. When the plant operator inserts the material to be treated into the chamber, a three-meter-thick concrete door is closed and the machine is activated in an external control room. The radioactive sources rise to the surface and interact with the material inside the irradiation chamber. When the dose recommended for the treatment is reached, the machine is turned off and the sources are collected, without their coming into contact with the operator or the treated materials (Figure 4).

Nonetheless, in the treatment of cultural heritage, the chemical and biological effects generated by the transfer of energy from the irradiator to the surroundings rely on the ability of gamma radiation to interact with critical cellular components to produce gene mutations and disrupt cell division. These effects are responsible for the potential biocidal effect of ionizing radiation and thus for the elimination of insects and other microorganisms that affect cultural heritage. Control of the dose absorbed

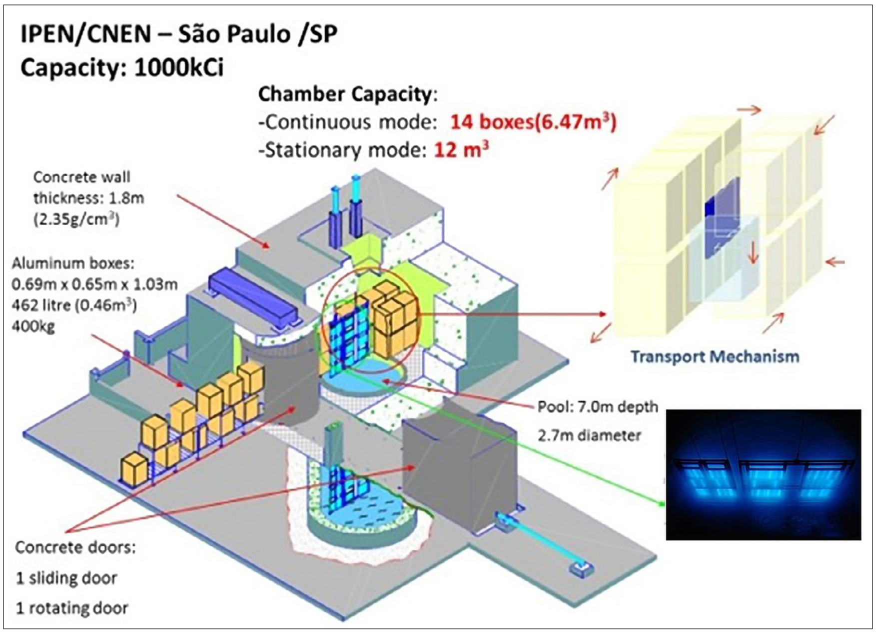

Figure 4. Working diagram of the cobalt-60 multipurpose gamma irradiator facility (IPEN-CNEN/SP)

Figure 5. Object being prepared for treatment in the multipurpose irradiator

by the object is a fundamental aspect of good treatment practice, but it requires an operator with the experience and technical knowledge needed to process cultural heritage. Furthermore, due to the complexity and technical sophistication of the irradiation treatments, they must be carried out in dedicated facilities. In this regard, the IPEN, with its multipurpose ^{60}Co irradiator, has become an institution of reference for the preservation of cultural heritage in Latin America.

The application of ionizing radiation to cultural heritage preservation has been studied since the 1950s (IAEA 2017, 34). Treatment properties include:

- There is no health risk to the conservator or other professionals handling the object, since the material does not become radioactive after treatment.
- With its high frequency and high energy, ionizing radiation is deeply penetrating, which allows the treatment of large volumes of material in their actual forms.
- Treatment does not change the mechanical and chromatic properties of organic materials such as wood, paper, leather, and feathers.
- For the elimination of pests such as xylophagous insects, moths, and microorganisms, the absorbed dose ranges from 0.5 to 25 kGy (Table 1).

Table 1. Summary of recommended gamma radiation doses for the disinfection of cultural heritage

Biodegradation agents	Recommended doses	Observations
Xylophagous insects, moths, silverfish, booklice, cockroaches	0.5 kGy up to 2 kGy	A dose of 2 kGy is considered to be sufficient for the eradication of any insect morph (egg, larva, pupa or adults)
Microorganisms: fungi and bacteria	8 ± 2 kGy 10 kGy is the maximum allowable dose	Considered a safe maximum dose for the most sensitive materials (cellulosic). A dose > 10 kGy may be considered in special situations

However, because radiation doses are cumulative, the total dose delivered by successive treatments can exceed the resistance limit of the material such that the object may become newly vulnerable, leading to conservation problems. Therefore, while ionizing radiation is a viable, non-toxic treatment, preventive conservation parameters should be continuously monitored.

MAE PROTOCOL FOR GAMMA RADIATION TREATMENTS

Thus far, the MAE-USP has treated 324 objects at the IPEN's multipurpose gamma irradiation facility (Figure 5). Treatment is performed free of charge for public institutions such as the MAE-USP. However, it is the responsibility of the institution to ensure the proper storage, transportation, and handling of the materials that will be treated.

The MAE-USP has developed a protocol for the decision-making process applied to objects that are candidates for treatment, including contaminated materials or new donations. An object that shows signs of contamination is immediately isolated. The decision-making protocol is presented as a flowchart in Figure 6.

If the object has any restrictions related to its composition (such as objects composed of glass, plastic, mother-of-pearl, or amber), gamma radiation treatment is not recommended, since the coloration of these materials may be altered (IAEA 2017, 102). If an object has already been treated by another technique, its repeated use is preferred to avoid the risk of cumulative radiation effects. When possible, the MAE-USP consults with representatives of the Indigenous groups from which the objects derived, to ensure that treatment decisions are made collaboratively. For objects with no restrictions, treatment with gamma radiation is carried out at the IPEN. The features of the main treatments used to combat contamination in collections, including chemical- and radiation-based treatments, are summarized in Table 2.

The flow of actions that precede treatment are described in the flowchart shown in Figure 7. The museum prepares a list of the objects to be treated and basic information, such as the identification and dimensions (volume) of the object, the raw material used to make it, a photograph of the object, and a description of the type of contamination. This information is forwarded to IPEN, where it will be used by the operator to define the dose needed for treatment. Once the treatment date and time are set, details regarding the transport of the object are agreed upon by both parties. The museum

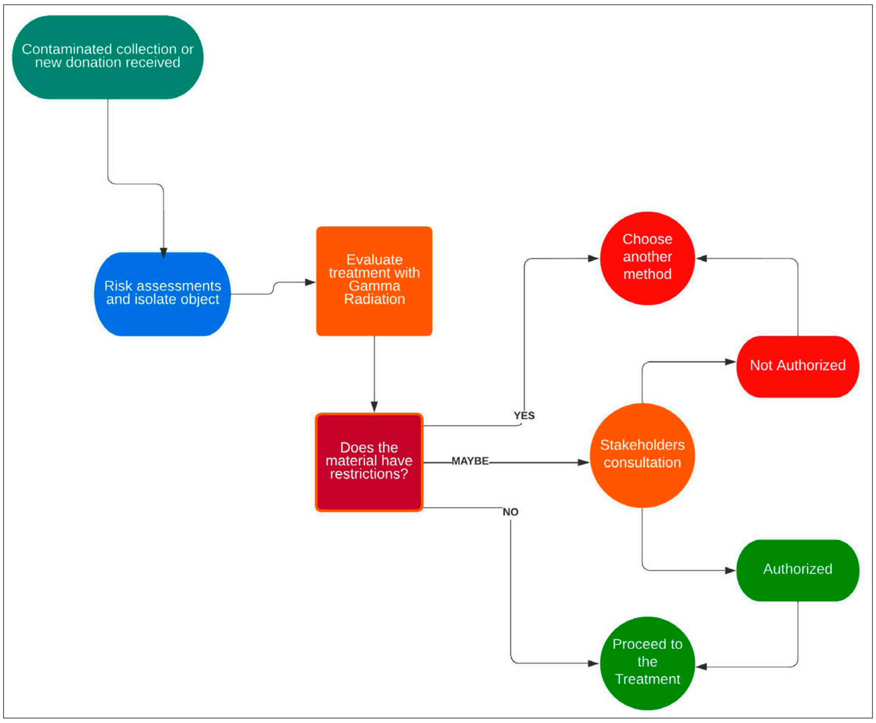

Figure 6. Decision-making flowchart

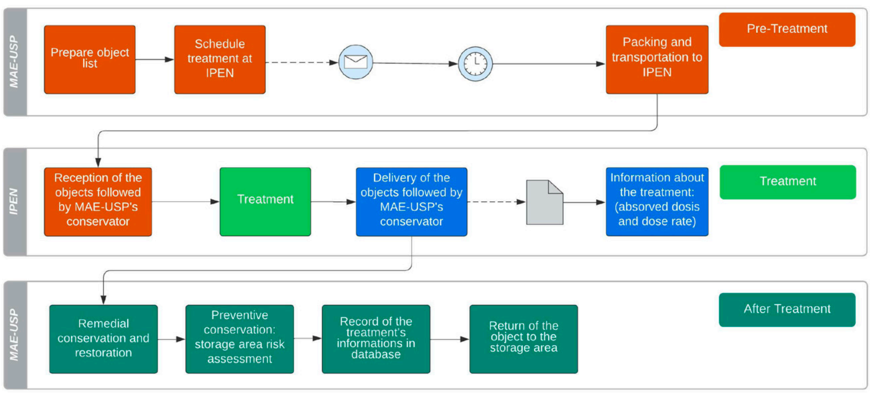

Figure 7. Treatment flowchart

staff is responsible for the object's transportation, and the conservator accompanies the object during its handling in the IPEN's facilities. After treatment is completed, the IPEN team reports the absorbed dose and the dose rate of the treatment performed. The data are entered into a database maintained by the MAE-USP that records the treatment history of a particular object, the date(s) that treatment(s) took place, and the dose of radiation used.

Further care of the treated objects at the MAE-USP is performed immediately after their return to the institution. Actions such as cleaning or damage stabilization are taken. Packing and storage areas are inspected to detect possible vulnerabilities that may have given rise to the contamination. Finally, the object is returned to the storage area, thus completing the treatment process.

Table 2. Traditional treatments and their pros and cons

Type of treatment	Method	Some examples	Pros	Cons
Toxic	Chemical products	Ethyl alcohol, isopropyl alcohol Formaldehyde Hydrogen peroxide, chlorinated compounds, ammonium quaternary	Affordable and simple method	Does not destroy bacterial spores Some have high toxicity to humans Risk of damage to objects
	Fumigant gases	Ethylene oxide Methyl bromide Phosphine Paradichlorobenzene	Rapid treatment (few hours or days) Effectiveness	Banned or restricted use in many countries High toxicity to humans Low predictability of gas penetration Risk to health and the environment Risk of damage to objects Staff need training
	Residual pesticides	Carbamates Inorganics pesticides Organophosphorus Organochlorines Pyrethrins and synthetic pyrethroids	Rapid treatment Effectiveness Residual effect on surfaces	Banned or restricted use in many countries High toxicity to humans Risk to health and the environment Risk of damage to objects
Non-toxic	Atmospheric gases	Cylinder: argon, carbon dioxide and nitrogen Generator: nitrogen	Affordable Effective if control parameters are observed Inert Safe for the objects and staff	Long treatment time (minimum: 4 weeks) Low predictability of gas penetration Rigid control of parameters to ensure effectiveness High cost of equipment (in case of generators)
	Physical removal	Brushes Vacuum cleaning Dry cleaning	Affordable and simple Safe for the objects	May not be effective in removing mold and insects inside the object Depends on careful inspection and on the pest species involved Requires repetition and continuous inspection Risk of contamination for staff Superficial removal
	Freezing	Freezer	Rapid treatment Safe for many objects and staff	Not suitable for fragile objects or those under stress Objects must be bagged properly Rigid control of parameters to ensure effectiveness
	Heating	Microwave Sun exposure	Affordable and simple Rapid Safe for many objects and staff	Humidity control is necessary Not suitable for fragile objects or those under stress Objects must be bagged properly Rigid control of parameters to ensure effectiveness
	Radiation	Gamma radiation	Rapid treatment Effectiveness Safe for many objects and staff Leaves no toxic residue Recommended in situations of: • Emergency interventions • Large structures or huge volumes of materials • Mass contamination • Natural disasters	Not recommended for amber, gemstones, glass and plastics High cost of the gamma radiation unit Operators must have training to treat cultural heritage and deep knowledge about the method

CONCLUSION

The MAE-USP has been working intensively with Indigenous groups during the past several years, despite the logistical and financial challenges posed by those efforts. These groups carry out curatorial activities at the museum whenever possible, as part of a larger effort at the decolonization of the institution. For example, a few months ago, Indigenous representatives visited the MAE-USP to participate in conversations about new conservation practices and how technology has been helping the MAE-USP to make use of more sustainable approaches to the conservation of objects. The museum's educational and conservation team invited the Kaingang leaders Ms. Dirce Jorge Lipu Pereira and Ms. Susilene Elias de Melo Deodato, managers at the Kaingang *Worikg* Museum from Vanuire (Museum of the Rising Sun), located in Tupã, São Paulo, to see the IPEN's facilities and learn more about the irradiation technique. Activities like these allow the museum to strengthen its relationships and increase trust with Indigenous groups (Figure 8), based on the recognition that these groups have an active role to play in the elaboration of new curatorial practices. These experiences have revealed the dynamic and social character of conservation and the importance of conservation practices beyond their technical and scientific aspects. Further visits of this type with other Indigenous groups are planned.

Figure 8. Technical visit to the IPEN

The IPEN's support in this decision-making process has been fundamental to increasing the MAE-USP's confidence in the use of ionizing radiation to treat its collections. Research related to the use of gamma radiation in the field of conservation must continue so that we can more confidently communicate the benefits of this technique both to our co-workers and our Indigenous partners and to the many cultural heritage institutions in Brazil that are unaware of its potential.

ACKNOWLEDGMENTS

The authors are grateful for research support from the Nuclear and Energy Research Institute (IPEN) and the International Agency of Atomic Energy (IAEA).

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To cite this article:
Delgado Vieira, A.C., P.A. Vásquez Salvador, and P. de Souza Santos. 2023. Moving toward sustainable conservation: Experience of the Museum of Archeology and Ethnology (MAE-USP). In *Working Towards a Sustainable Past. ICOM-CC 20th Triennial Conference Preprints, Valencia, 18–22 September 2023,* ed. J. Bridgland. Paris: International Council of Museums.