Mobile and Non Chemical Pest Control Measure Applicable to Small Size Museums

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Mobile and Non-Chemical Pest Control Measure Applicable to Small-Size Museums

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1. Introduction

Japan's hot and humid environment means there is a high risk of damage from pests and fungi in Japanese museums, and this is a challenge that must be addressed. In considering this issue, I would first like to provide a breakdown of the different types of museums in Japan.

According to government statistics from March 27, 2017, there are 1,256 museum facilities in Japan. The following is a detailed breakdown of the numbers and types of museums: 152 general museums; 106 science museums; 451 history museums; 441 art museums; 16 open-air museums; 35 zoos; 10 botanical gardens; 7 zoological and botanical gardens; and 38 aquariums.

Of these, the museum facilities that require pest control treatment in order to conserve the objects in their collections include: 152 general museums; 451 history museums; 441 art museums; and 16 open-air museums. In all, there are 1,060 relevant facilities, representing 84% of the total number of museum facilities in Japan. The majority of objects and works owned by these museums are organic materials, which are attractive food sources for pests. Further, because the objects are stored in close proximity to one another, when an outbreak of pest damage occurs, there is a high risk that the damage will spread rapidly to the surrounding objects. Therefore, pest control treatment in Japanese museums is an important task in the storage and conservation of museum collections.

2. Trends in Pest Control Treatment at Japanese Museums

Insecticidal treatment equipment was introduced to Japanese museums in 1955, when a vacuum fumigation device was installed in the office of the Shosoin Treasure House in Nara Prefecture. This was the first domestic insecticidal treatment device for cultural properties, and the agent used in the treatment process was methyl bromide. The Shosoin Treasure House office is responsible for the storage and management of the treasures in the Shosoin Treasure House collection, which includes rare and valuable assets of Emperor Shoumu, who built the Heijo Capital in the middle of the eighth century, as

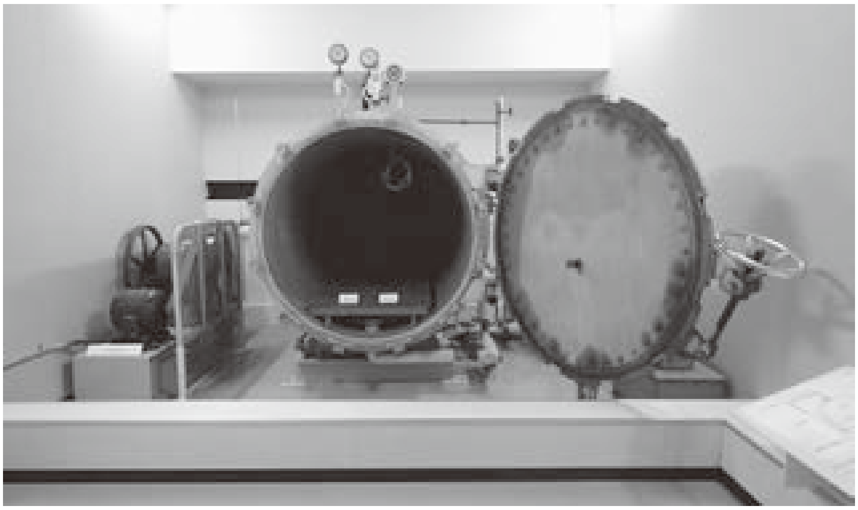

Photo 1 The vacuum fumigation device (Image courtesy of Kyushu National Museum)

well as altar fittings used in important Buddhist ceremonies such as the *Todaiji Daibutsu Kaigen-e* (Eye-Opening Ceremony of the Great Bronze Buddha). The Shosoin Treasure House therefore houses cultural assets of enormous historical and artistic significance. The vacuum fumigation device is now on display at the Kyushu National Museum as an exhibit to show the history of insecticidal treatment at Japanese museums (Photo 1).

The Shosoin Treasure House case was the starting point for insecticidal treatment in museums, and the next significant milestone came in the late 1970s with the development of a compound agent of methyl bromide and ethylene oxide, which became a certified drug for cultural properties. This led to a widespread increase in the practice of fumigation treatment in museums across Japan. The heavy use of this chemical agent is demonstrated by the fact that annual domestic consumption rose to 60 tons around the time that fumigation treatment became widespread. These developments had an impact on the pest control measures employed at the National Museum of Ethnology, Osaka (hereafter “Minpaku”), where I am based, and in 1979, Minpaku started its own program of storage fumigation using this chemical agent. This practice had become a popular method of storage management among Japan’s museums because it meant that harmful pests could be dealt with before they were able to inflict any damage. However, there was much debate on the wisdom of using large quantities of highly toxic gas in museum facilities, and there were even calls to abandon the practice. Ultimately, no truly effective alternative method was discovered, and while there was an awareness of the associated problems, insecticidal treatment methods that relied on chemical agents continued to be employed in Japan.

Against this backdrop, Japan subsequently experienced another major turning point in 1995 when it was decided to completely abolish the use of methyl bromide by 2005. This followed the official designation of methyl bromide as an ozone-depleting substance in the Montreal Protocol, an international treaty that Japan had ratified. There was now a sudden impetus in Japan to develop new techniques for pest control treatment by 2005. Around this time, a new chemical agent was developed to replace methyl bromide (Kigawa et al. 1999). At the same time, techniques for non-chemical pest control treatment were developed (Kigawa et al. 2000), and a survey was conducted of the non-chemical pest control treatment methods that were already in use at museums in the West (Kigawa et al. 2003). The methods that attracted particular attention were carbon dioxide treatment, low oxygen concentration treatment, and thermal methods (heating, low temperature). Of these, it was found that carbon dioxide treatment could be used with a variety of different materials and implemented with a relatively easy system, so this was the method Minpaku chose to introduce in 2004. In the next sections, I will outline the carbon dioxide treatment process and give an example of how it has been employed at Minpaku.

3. An Outline of Carbon Dioxide Treatment

The source gas for carbon dioxide treatment is the carbon dioxide produced and collected as a by-product from oil refineries, chemical plants, and the manufacturing process of dry ice. In other words, the production method uses recycled carbon dioxide that has already been discharged as waste, so no new carbon dioxide is produced. This is important as carbon dioxide is considered to be one of the causes of global warming.

The conditions required for carbon dioxide treatment to be effective as a pest control treatment are as follows: the treatment temperature must be 25°C; the concentration of carbon dioxide should be between 60 and 75%; and the treatment period should be 14 days. One of the key aspects of carbon dioxide treatment is that the system to deploy it is simple. For example, the treatment process can be carried out inside a tent of any size constructed with a gas barrier plastic sheet (Photo 2). If there is a portable inlet and exhaust port for the carbon dioxide and as long the temperature can be maintained at 25°C in the space, the treatment can be carried out anywhere (Hidaka et al. 2002). A schematic diagram of a carbon dioxide treatment system is shown in Photo 3.

4. Example of Carbon Dioxide Treatment for Small-Scale Facilities

As an example of carbon dioxide treatment for small-scale facilities, this paper will present a case of carbon dioxide treatment technnical transfer that was carried out as one of the Minpaku's support activities following the Great East Japan Earthquake, along with a second case of carbon dioxide treatment technical transfer carried out at a school facility used as a storehouse for folk cultural properties in Murakami City, Niigata Prefecture.

4.1 Support Activities for the Great East Japan Earthquake

In the wake of the Great East Japan Earthquake, I helped to carry out carbon dioxide treatment technical transfer activities in the disaster-hit area with the aim of preventing pest damage to cultural properties affected by the disaster.

Photo 2 Objects to be treated gathered in a gas barrier plastic sheet (Image by the author, August 18, 2017)

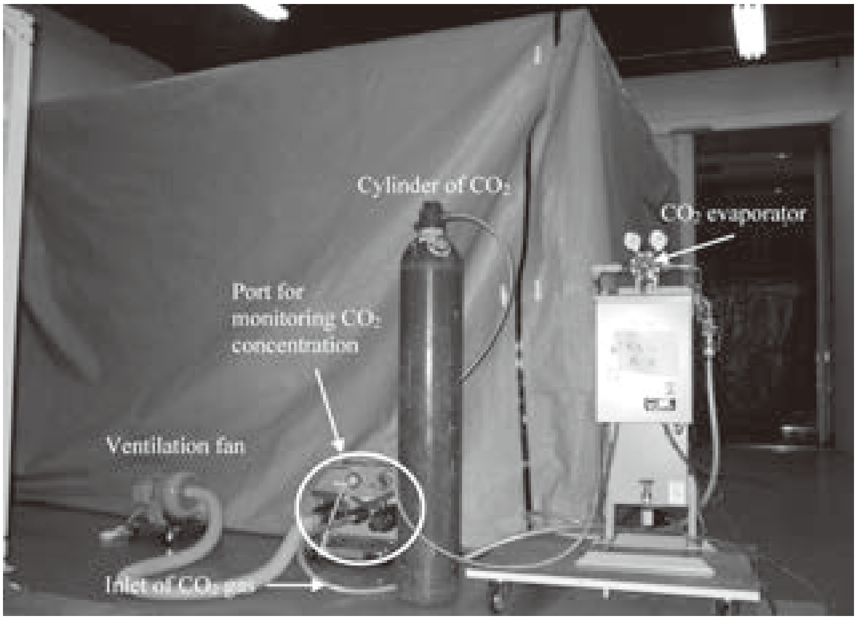

Photo 3 The carbon dioxide treatment system: Tent size (W4000mm × D4000mm × H2500mm) (Image by the author)

Photo 4 The disaster-hit area (Ishinomaki City, Miyagi Prefecture)
(Image by the author, May 16, 2011)

Photo 5 The disaster-hit area (Kesennuma City, Miyagi Prefecture)
(Image by the author, June 16, 2011)

First, I would like to briefly review the Great East Japan Earthquake. At 14:46 on March 11, 2011, an earthquake occurred in the Pacific Ocean off the coast of the Tohoku region. Following the earthquake, a huge tsunami hit the coast of Japan, causing damage on an unprecedented scale (Photos 4 and 5) and precipitating the accident at the Fukushima Daiichi nuclear reactor. I joined the rescue efforts for the cultural properties affected by the disaster, participating in the rescue of folk artifacts in six regions of Miyagi Prefecture and two regions of Iwate Prefecture (Figure 1). The first task in rescuing these cultural properties was to search for the artifacts buried in the rubble (Photo 6) and then to retrieve them while removing rubble from inside the buildings (Photo 7). The next task was to move these rescued artifacts to a safe location where they could be stored temporarily. It was at the temporary storage locations that the problem of pest damage first emerged. These storage locations, which were secured at the time of the disaster to house the disaster-affected cultural properties, were only intended to be temporary. These facilities were not like museums; for the most part, we were just provided with places that could be locked up and could keep off the rain, but most of them were places that pests could easily permeate. Usually when a disaster occurs, cultural artifacts are quickly moved from their temporary storage locations to places where the environment is well suited to storing them. However, because of the sheer scale of the damage following the Great East Japan Earthquake, it was difficult to find suitable storage locations for the cultural properties, and the temporary storage facilities ended up becoming long term—in some cases being used for over a year—so concerns over pest damage grew. As a counter-measure, I decided to carry out a carbon

Figure 1 Map of Japan and disaster-hit areas that Minpaku visited in support ( )

Photo 6 The rescue efforts for cultural properties buried in the rubble
(Image by the author, June 22, 2011)

Photo 7 The rescue efforts while removing rubble
(Image courtesy of Tomomi Wadaka, June 22, 2011)

Photo 8 The lecture on the method of carbon dioxide treatment
(Image courtesy of Tomomi Wadaka, September 20, 2013)

dioxide treatment workshop in the disaster area for the disaster-affected cultural properties. The workshop was held at Tohoku Gakuin University.

Tohoku Gakuin University proactively participated in the efforts to rescue the cultural properties affected by the earthquake and provided one of the temporary storage locations. However, the environment of this temporary storage location was far from ideal. More than a year had elapsed since objects were put into temporary storage, so concerns had grown over a possible outbreak of pest damage. I carried out a technical transfer so that the carbon dioxide treatment could be employed at Tohoku Gakuin University. To do this, I first went through the approximately 4,000 disaster-affected cultural properties that were stored temporarily at Tohoku Gakuin University, checking the condition of each one, and then selected the objects that needed carbon dioxide treatment. The first part of the technical transfer workshop was a classroom lecture in which I gave an overview of pest control treatment for cultural properties and explained the safety aspects of carbon dioxide. Having completed this, I then taught the students about the method of carbon dioxide treatment (Photo 8). Next, in a practical session, the students practiced how to assemble the treatment bag, how to handle disaster-affected cultural properties (Photo 9), and how to use carbon dioxide (Photo 10). The result was that the carbon dioxide treatment was carried out successfully without damaging the objects. Once the pest control treatment had been carried out, the objects were moved to and stored at a new storage location that had been prepared for the purpose.

Photo 9 The practical training on handling disaster-affected cultural properties
(Image courtesy of Tomomi Wadaka, September 20, 2013)

Photo 10 The practical training on how to use carbon dioxide
(Image courtesy of Tomomi Wadaka, September 20, 2013)

4.2 Storehouse in Murakami City, Niigata Prefecture

In September 2016, an outbreak of pest damage was discovered in Murakami City at a storehouse that had formerly been a school building but was no longer used as such (Photo 11). The area is snow-bound in winter, so I first waited for winter to pass; in May 2017, before it got warm, I carried out the task of isolating the pest-damaged objects (Photo 12) and cleaning the storehouse (Photo 13). After that, I waited until the summer, when it would be possible to maintain a temperature of 25°C or above, and carried out the carbon dioxide treatment in August. The decision to carry out the carbon dioxide treatment at this time was based on the results of an ongoing study monitoring changes in temperature and humidity, which had concluded that the only time in the year it was possible to maintain the storehouse temperature at 25°C or above for a period of two weeks was between the end of July and the middle of August.

Photo 11 Confirmation of occurrence of pest damage
(Image by the author, September 23, 2016)

Photo 14 shows the pest damage caused to a museum object, while Photo 15 shows the pest damage caused to the shelves on which the objects were stored. The pest that had damaged the object was the *Nicobium hirtum*, a type of beetle well-known for damaging cultural properties (Photo 16). The body of an adult *Nicobium hirtum* is entirely covered with short hairs and is between 4 mm and 6 mm in size. They cause damage to the cultural properties when they are larvae by feeding on the inside of wooden components. When the larvae become adults, they make holes in the wood as they emerge to the surface. The females mate and lay their eggs in the wood, and a new

Photo 12 The task of isolating the pest-damaged objects
(Image by the author, May 26, 2017)

Photo 13 The task of cleaning the storehouse (Image by the author, May 26, 2017)

Photo 14 Pest damage caused to objects (Image by the author, September 23, 2016)

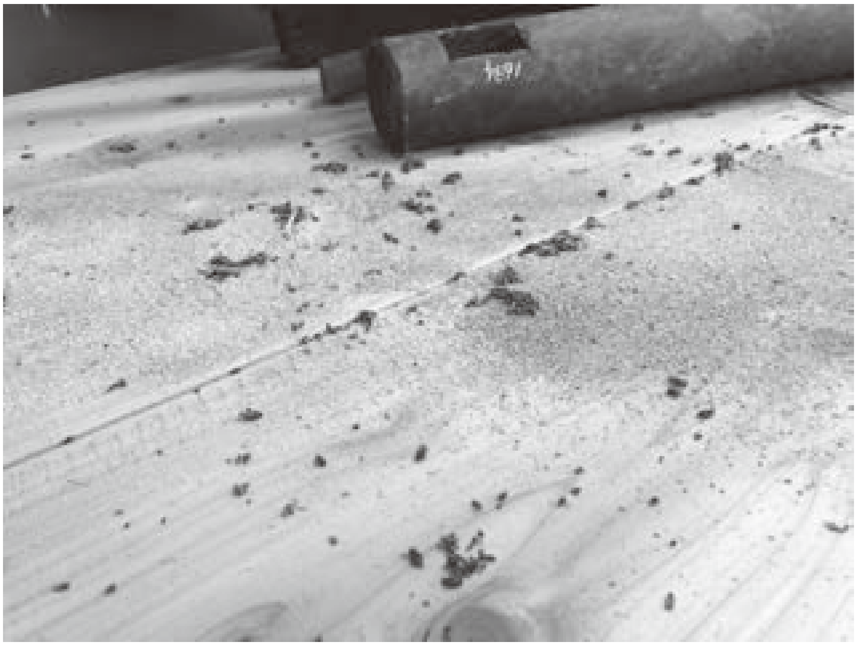

Photo 15 The shelf where the pest-damaged objects were stored
(Image by the author, September 23, 2016)

Photo 16 *Nicobium hirtum*
(Image courtesy of Yukio Komine)

generation of larvae then feed on the wood's interior, causing further damage.

When carrying out carbon dioxide treatment in this case, I decided to introduce daily Integrated Pest Management (IPM) activities for preventing the occurrence of pest damage as part of the management strategy for the storehouse. To this end, I carried out workshops on cleaning the storehouse and isolating the pest-damaged objects. IPM is a method of pest management that does not merely rely on chemical agents but aims to prevent the occurrence of biological damage and was originally developed by the agricultural sector. In recent years, use of this method to prevent biological damage has spread to places such as museums, art galleries, libraries, record offices, and archives. However, it is not possible to simply transfer IPM methods from the agricultural sector to museums, art galleries, and libraries, where cultural properties are stored. IPM methods must be adapted to suit the environment of each individual facility. By combining environmental management activities such as cleaning and temperature/humidity control with prevention methods such as chemical agents, it is possible to eradicate damage to cultural properties caused by pests or mold.

The Murakami City officials participated actively in the technical transfer workshop and learned how to deal effectively with an outbreak of pest damage. As with the workshop held at Tohoku Gakuin University, the technical transfer of carbon dioxide treatment was achieved by giving the students hands-on practice in administering the treatment (Photo 17). There was a concern that it would not be possible to maintain the requisite treatment temperature of 25°C, so on this occasion, the treatment period was extended to three weeks, one week longer than usual. Figure 2 shows the change in temperature and humidity during the treatment period, while Figure 3 shows the change in carbon dioxide concentration. These results show that both the treatment temperature and level of carbon dioxide concentration required for pest extermination were achieved.

Photo 17 The workshop on carbon dioxide treatment in Murakami City (Image by the author, July 31, 2011)

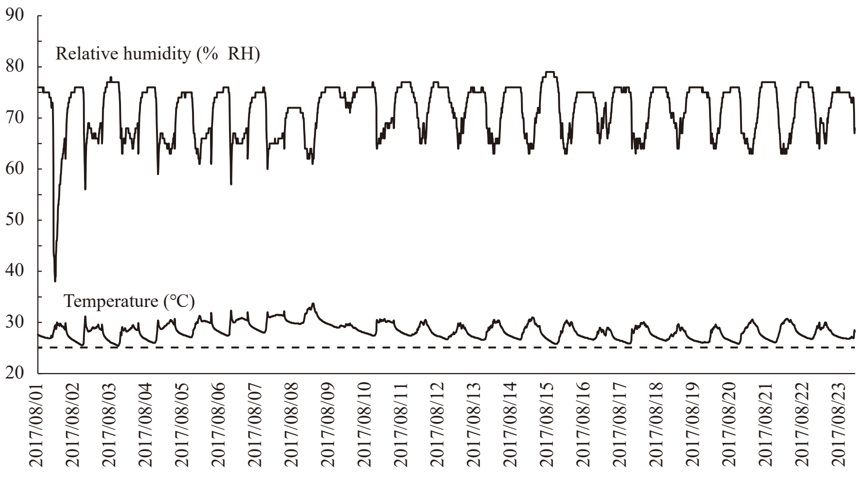

Figure 2 The change in temperature and humidity during the treatment period

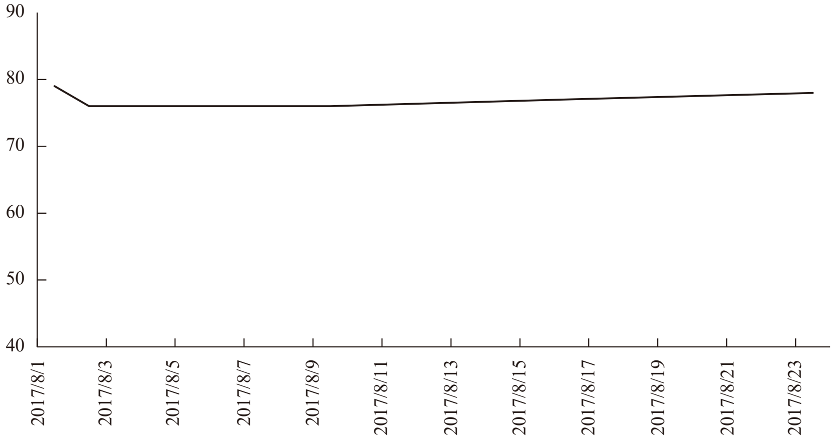

Figure 3 The change in concentration of the carbon dioxide during the treatment period

5. Conclusion

In this paper, I have reported on the use of carbon dioxide treatment at small-scale facilities as an example of a non-chemical, mobile pest control treatment that can be deployed at such facilities. As demonstrated in this paper, carbon dioxide treatment can be administered using a simple system and can be applied to various materials. In terms of pest control treatment at museums, therefore, it can be a highly versatile method, and this is, indeed, one of the main advantages of carbon dioxide treatment. On the other hand, there are some weak points; carbon dioxide does not permeate through wood with a thickness of 10 cm or more, and there are pests, such as longicorn beetles, on which the treatment is largely ineffective. If carbon dioxide treatment is to be introduced at a museum, it is important to be aware of and understand these advantages and disadvantages. The same could, of course, be said when introducing any other method of pest control treatment at a museum.

Future conservation of cultural properties will require the development of the most effective means of conservation and the selection of the most appropriate methodology based on each museum's specific environment. This should be in a form that also answers wider environmental problems, of which there is an increasing awareness as a shared challenge for all of society. The same is true of the pest control treatment method presented in this paper, and with this point in mind, I will continue to strive for a conservation of museum collection that makes full use of the knowledge offered by conservation science.

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