Sustainable Collection Management in a 1970s Building : A Case Study of the National Museum of Ethnology, Osaka

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Sustainable Collection Management in a 1970s Building: A Case Study of the National Museum of Ethnology, Osaka

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1. Introduction

Since the end of the twentieth century, the museum community has been called upon to give further consideration to environmental impact. Two specific environmental issues that have a major impact on Japanese museums are the protection of the ozone layer and global warming.

In response to the issue of ozone layer protection, museums have drastically reconsidered their policies regarding insect repellents and insecticides because since about the late 1970s, Japan had used a mixture of methyl bromide and ethylene oxide for the gas fumigation of cultural properties. However, methyl bromide was regulated as an ozone-depleting substance under the Montreal Protocol on Substances that Deplete the Ozone Layer, and its production was abolished at the end of 2004. Measures taken by museums against biological damages shifted from what had been a conventional insecticide-centered approach relying on gas fumigants toward an emphasis on preventive measures. In addition to the increased demand for developing and implementing pest control treatments that do not use gas fumigants (see Supplement to Part I: Environmentally Friendly Pest Control Treatment Facilities at the National Museum of Ethnology, Osaka), an urgent need has arisen to establish collection management strategies based on the concept of Integrated Pest Management (IPM).

Global warming has led to calls for initiatives to reduce greenhouse gas emissions. Currently in Japan, the majority of our energy supplies, including gas and electricity, rely on fossil fuels, and energy consumption leads directly to carbon dioxide emissions, which contribute to global warming. In addition to the conservation of their collections, museums have entered an era in which they must consider the extent to which they can moderate the conditions of their conservation environments in terms of temperature and relative humidity (RH), as well as how they can realize sustainable collection management and environmental control practices. The round table discussion convened on the theme of “climate change” by the International Institute for Conservation of Historic and Artistic Works (IIC) in 2008,[1] among other initiatives, points to the recent increased interest in the impact of climate change on museum collections.

In this paper, I aim to provide a comprehensive summary of findings on the latter environment issue, i.e. the question of how best to establish an environmentally conscious museum environment at the National Museum of Ethnology, Osaka (hereinafter "Minpaku") while prioritizing the conservation of objects borrowed from overseas as well as the objects in our own collection (Sonoda et al. 2017). Then, our efforts to develop more affordable and environmentally sustainable collection management in an old building constructed in 1977 will be illustrated in two examples, with reference to energy use. One example involves the temperature and RH settings for general storerooms where an energy-saving regimen was introduced after the Great East Japan Earthquake of March 2011 (Sonoda 2015). The other is the use of LED lighting to replace halogen spotlights in the main exhibition halls since FY2015 (Sonoda et al. 2016). In each case, basic concepts and conservation issues affecting the selection of the conditions and/or requirements will be discussed and their energy-saving cost performance presented.

2. Establishing an Environment for Objects Borrowed from Institutions Overseas

With the growing popularity of cultural exchange on a global scale, opportunities to utilize museum collections have rapidly increased, including the exhibition of borrowed objects from other museums in Japan as well as museums around the world. In this context, objects from the Western countries are often borrowed on the condition that they be displayed in a constant environment of 20±2℃ and 50±5% RH.

Unlike Europe and North America, however, Japan is situated in a temperate and humid climate zone. Figure 1 shows the highest, average, and lowest monthly temperatures for Osaka[2)] and Paris[3)] in 2017. The average summer temperatures in Paris ranged from 23℃ in July to 25℃ in August and 18℃ in September, whereas the temperatures for the corresponding months in Osaka were 29℃, 29℃, and 24℃, respectively, in each case around 5℃ warmer. While temperature conditions of 20±2℃

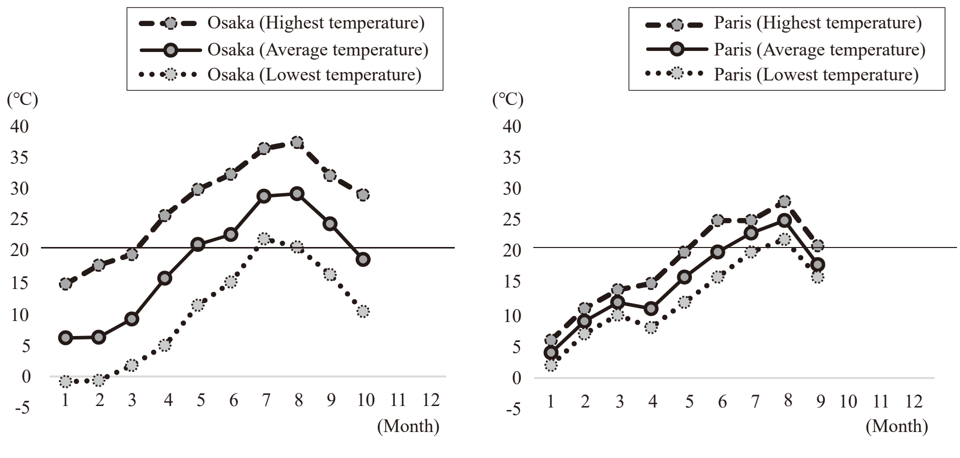

Figure 1 Monthly highest, average, and lowest temperatures for Osaka (left) and Paris (right) (2017)

may be applicable in Paris and other European cities, in Osaka, the difference from the outside temperature approaches 10℃. In addition, the number of days on which the highest temperatures in Osaka exceeded 35℃ accounted for six days in July[4)] and nine days in August,[5)] which might suggest that a set room temperature of 20℃ would certainly not offer a comfortable environment for museum visitors.

At Minpaku, we borrowed objects from overseas for use in two special exhibitions that were held during the summer. Below, I will introduce the steps taken for each of these exhibitions in 2004 and 2017, respectively.

2.1 2004 Special Exhibition: "The Arabian Nights"

For our 2004 special exhibition, "The Arabian Nights," we borrowed rare books from a European country. In securing the loan of these materials, the terms of the contract stipulated display conditions of 20±2℃ and 50±5% RH. As the exhibition was held from the beginning of September, when outside temperatures were still quite warm, the temperature in the exhibition galleries was set at 25℃ to provide museum visitors with a comfortable visit, but the display environment for the books was arranged separately to meet the loan conditions.

To this end, we devised a way to better control the temperature and RH inside the closed display case with a unit that combined a temperature and RH control device with air circulation ducts (Hidaka et al. 2009; Sonoda et al. 2017) (Figure 2). The temperature was controlled by using a heater to warm air that had been cooled by a refrigeration unit. RH was controlled by humidifying air that had been dehumidified using the same refrigeration unit. After the air was modulated in terms of temperature and RH, it was then circulated through the display case by a fan inside the temperature/RH control unit. The temperature/RH control unit and display case were connected by two air flow ducts and three air intake ducts. The books were placed into acrylic boxes inside the display case to prevent the flow of cool air from touching the books directly, and a further moisture regulating effect was expected from the additional placement of buffered silica gel inside the acrylic boxes.

Figure 3 shows the temperature and RH fluctuations over the course of the exhibition period. While the temperature in the exhibition galleries at the beginning of the exhibition was 25℃, as autumn set in, the temperature was gradually lowered until it was set at 20℃. On the other hand, we can confirm that the temperature inside the display case and inside the acrylic boxes containing the books remained at a constant 20℃ for the duration of the exhibition. While some fluctuation in terms of RH can be seen inside the exhibition galleries, a constant RH was maintained throughout inside the acrylic boxes containing the books.

We were thus able to satisfy the conditions of the overseas loan by affixing a temperature and RH control device to the display case. Nevertheless, doubt has arisen as to whether a temperature of 25℃ is really outside the tolerable range for all objects. At Minpaku, the temperature settings for the museum's exhibition galleries and storerooms have been set at 26℃ since the museum's founding, and no problems have arisen for the ethnographic objects so far. In some cases, after considering the condition and the nature

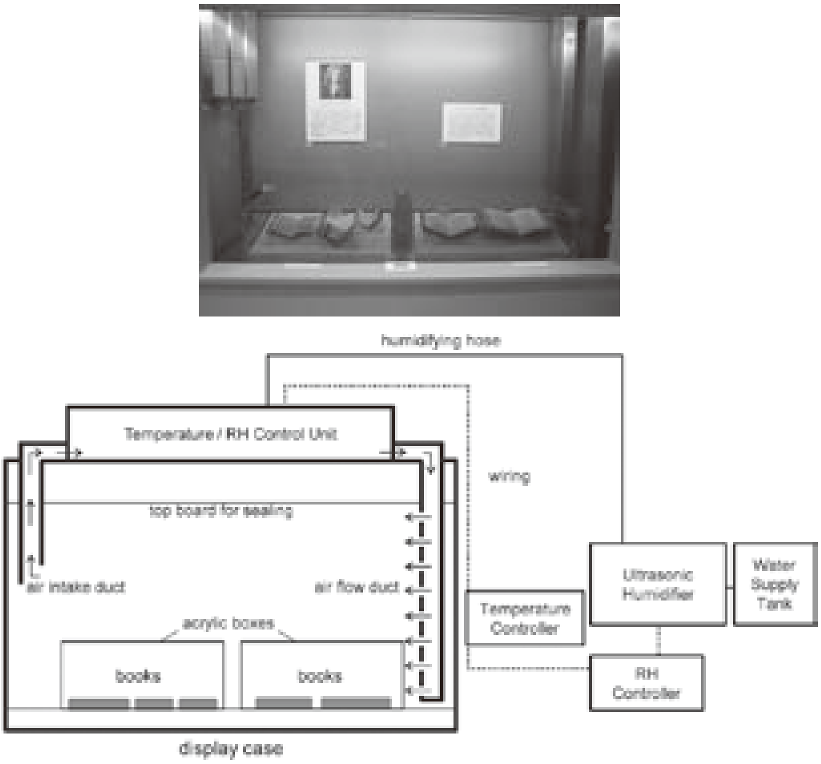

Figure 2 A display case affixed with a temperature and RH control unit and its schematic

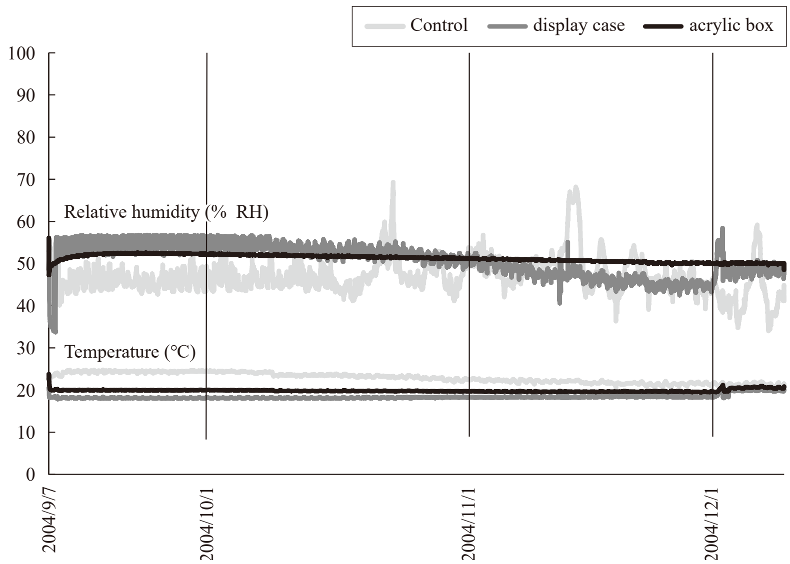

Figure 3 Temperature and RH fluctuations in the exhibition gallery, inside the display case, and inside the acrylic box over the exhibition period

of the materials comprising the object, rather than ensuring localized air conditioning to 20°C, it would be more realistic to enter into advance discussions with the lender to consider if a temperature setting of 25°C for summer is acceptable or not, which seems to offer a solution that is simultaneously more economically feasible and environmentally conscious.

2.2 2017 Special Exhibition: "Revisiting Siebold's Japan Museum"

The special exhibition "Revisiting Siebold's Japan Museum" commemorating the museum's fortieth anniversary was staged at Minpaku as the final venue following a tour of four Japanese museums. Because the exhibition period was from August 10 to October 10, coinciding with the hottest period of the year, Minpaku arranged to negotiate with lending institutions in advance, successfully obtaining their approval to make an exception by setting the museum's temperature conditions at 25°C rather than 22°C. In terms of RH, while varying tolerable ranges were indicated depending on the nature of the materials comprising the objects, an RH setting of 55% was applicable to most. Accordingly, it was decided that RH settings would be set to 55% for the exhibition galleries and to 50% only for the metal objects inside the cases.

Figure 4 shows the temperature and RH fluctuations in the exhibition galleries and inside the display case containing the metal objects. The display case board was covered with a 0.5 mm-thick layer of aluminum foil to increase hermeticity and was provided with silica gel adjusted to 50% RH. During the two months of the exhibition, we can see

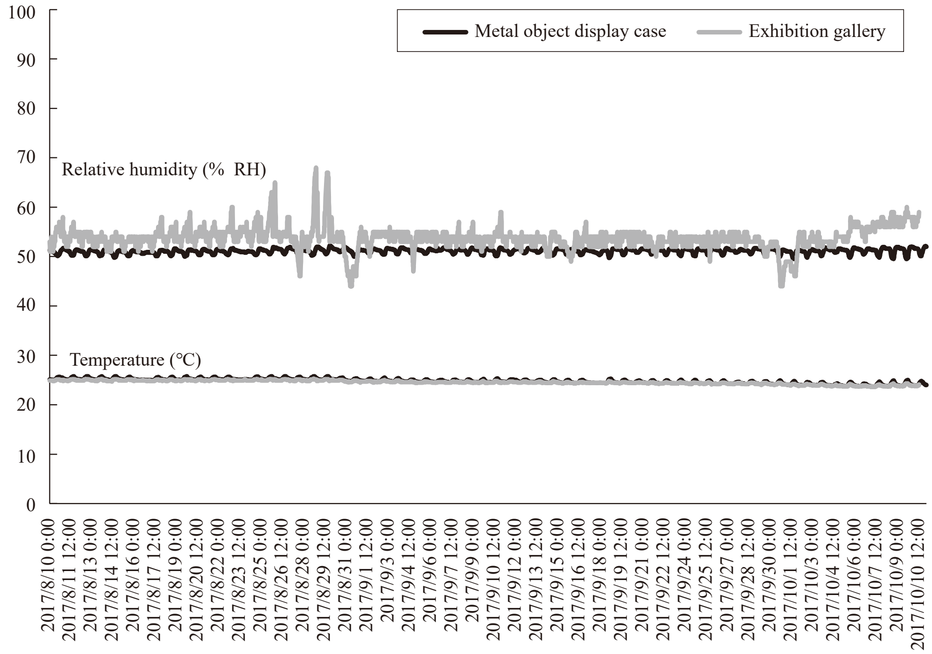

Figure 4 Temperature and RH fluctuations inside the display case containing metal objects

that a temperature of 25°C was maintained inside both the exhibition galleries and the display case. While the RH fluctuated between 45% and 65% in the exhibition galleries, it was successfully kept to about 50% inside the display case.

After the two-month exhibition, the objects were returned to the lending institutions without incident.

3. Establishing an Environment for Objects in the Museum's Own Collection

At Minpaku, we collect objects relating to people's life and culture, and as of March 2017, our collection contained as many as 343,581 objects. Neither the building structure nor the design of the museum, which first opened in 1977, were planned with energy conservation in mind as was done for the Kyushu National Museum, which was built in the twenty-first century, nor was it envisioned that the museum would use anything but fossil fuel energy. If we could change the building materials and design of the building so that they would be less susceptible to fluctuations in the temperature and RH of the outside atmosphere, it would be possible to realize more efficient and economical environmental conditions. Even so, such a comprehensive and drastic initiative is not something that can be realized overnight. Given these circumstances, I would like to summarize how we have been working toward realizing environmentally friendly and sustainable collection management practices using the two examples of revising climate control practices and shifting to LED lighting.

3.1 Air Conditioning Settings in Storerooms

At Minpaku, we manage air conditioning (AC) for museum collections in an efficient and economic manner by dividing it into three levels (respectively, for special storerooms, general storerooms, and exhibition galleries, in order of descending rigor of control). Five special storerooms have been set aside for objects, accounting for approximately 10% of our collection (weapons, carpets, lacquerware, fur/leather/feather products, and textiles). Temperature and RH settings in these special storerooms are set to maintain constant levels throughout the year according to the nature of their respective materials. Climate control settings for the general storerooms that contain the large majority of our ethnographic objects (approximately 90%) are set to maintain average temperature and RH levels so as to be able to accommodate a variety of materials. Air conditioning is operational every day during working hours (8:20–18:00). Temperature settings are 26±2°C in summer and 20±2°C in winter, adjusted by increments of 0.5°C every week during the transitional seasons of spring and autumn, while RH settings are maintained at 52±5% RH throughout the year (Table 1). With regard to AC for the exhibition galleries, as with the general storerooms, temperature settings vary by season while RH settings are maintained at a constant level throughout the year. AC is operational only during the museum's opening hours. Temperature controls are occasionally subject to fine adjustments to accommodate requests from museum visitors.

The Great East Japan Earthquake that occurred in March 2011 represented a major

Table 1 Temperature and RH settings for general storerooms targeted for power-saving measures (before and after the Great East Japan Earthquake)

	Spring	Summer	Autumn	Winter
~FY2010	Adjustment made in increments of 0.5°C per week 52±5% RH 8:20–18:00	26±2°C 52±5% RH 8:20–18:00	Adjustment made in increments of 0.5°C per week 52±5% RH 8:20–18:00	20±2°C 52±5% RH 8:20–18:00
FY2011	Adjustment made in increments of 0.5°C per week 52±5% RH 8:20–18:00	Power saving test 12:00–15:00 OFF during 12:00–15:00 for six test days	Power saving AC off	Power saving 20±2°C 17:30–21:30 6:00–9:00
FY2012	Power saving AC off	Power saving 26±2°C 24hours only Wednesday and Sunday	Power saving AC off	20±2°C 52±5% RH 8:20–18:00

opportunity for rethinking climate control policies at Minpaku. As a result of our review of climate control settings for general storerooms in response to requests to conserve energy after the earthquake, we undertook to turn the AC off in the autumn of 2011 and 2012, to reduce AC usage in the winter of 2011, to turn the AC off in the spring of 2012, and to reduce AC usage in the summer of 2012. In this case, the AC was turned off during the transitional seasons (autumn 2011 and 2012, and spring 2012) when the outside air temperature was stable. During the winter of 2011, we sought to maintain RH within the stipulated range mentioned above by running the AC only at night and in the early morning hours, when less power would be consumed than at other times during the day. In the summer of 2012, we were asked to find energy savings of 15% (later 10%) relative to 2010. To that end, we ran the AC for 24 hours on Wednesdays (the museum's regular holiday) and Sundays (when fewer staff are present) and to turn the AC off on other weekdays (Table 1) (Sonoda 2015; Sonoda et al. 2017). It should also be noted that this energy savings measure targeted only five of the seven general storerooms least likely to be affected by the outside temperature.

Figure 5 compares the temperature and RH fluctuations in the general storerooms for a year-round normal regimen (upper graph) versus the energy saving regimen (lower graph). The state of temperature and RH control when the AC was turned off in the autumn of 2011 and spring of 2012 does not seem to have differed markedly from the years when the AC was in operation. We can see that the absence of weekly temperature adjustments seems to have led to a gentler transition for both temperature and RH. In the case of reduced AC, we find that daily AC operation, even at a reduced level, as in the winter of 2011, is better at suppressing temperature and RH swings than the alternation of no AC with 24 hours of AC, as in the summer of 2012.

Based on this verification, from FY2014, we switched to a new climate control regimen that paid more attention to power-saving effects (Table 2). During the spring and

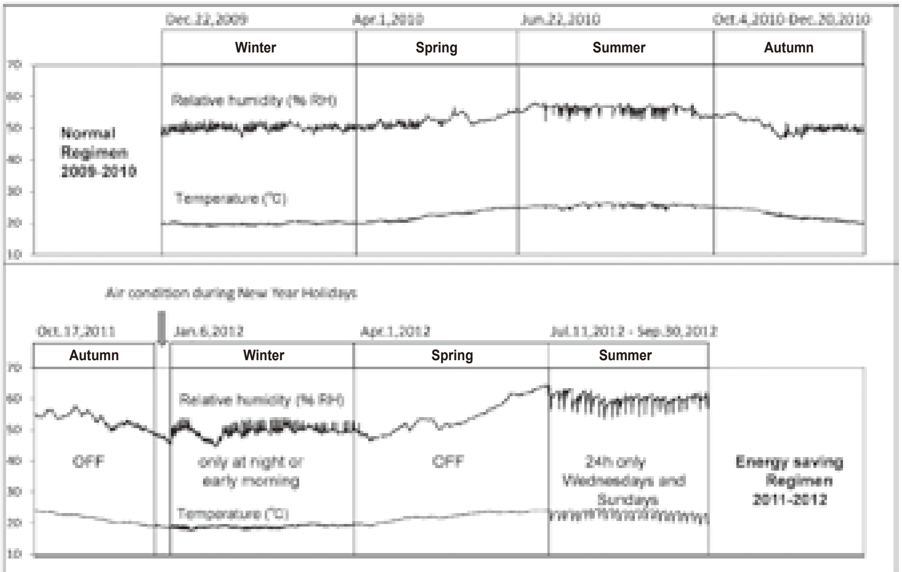

Figure 5 Comparison of temperature and RH fluctuations in the 8-hour climate control regimen (upper graph) versus the power-saving regimen (lower graph)

Table 2 Temperature and RH settings for general storerooms targeted for power savings (from 2014)

	Spring	Summer	Autumn	Winter
FY2014~	AC off	26±2℃ 52±5% RH 8:20−18:00	AC off	26±2℃ 52±5% RH 8:20−18:00
	—	Rough guidance to start air conditioning: above 26℃ or 65% RH	—	Rough guidance to start air conditioning: too cool for working or less than 40% RH

autumn (transitional seasons), the AC is shut off to allow the temperature to change naturally. In the summer months, we follow the rough guideline of turning on the AC when the temperature in a room exceeds 26℃ (the temperature setting value for cooling) or when RH exceeds 65%. In this way, while we are somewhat dependent on the outside temperature, on average, the net effect has been to delay the start of AC cooling. The guideline for AC in the winter is to turn on climate controls when staff in the storerooms feel that it is too cold to work or when RH falls below 40% (Sonoda et al. 2017). It should also be noted that careful attention is given to the year-round monitoring of temperature and RH, and in cases where the RH value deviates significantly from the set value of 52% when AC heating or cooling is turned on, RH settings will be finely calibrated to ensure that the change occurs gradually.

One factor that has contributed to making such a solution possible is the liaison meeting that is held once every two weeks to discuss issues relating to the AC. In addition to the researchers specialized in preventive conservation, the staff member in charge of temperature and RH monitoring, staff in charge of the storerooms, staff from the facilities management unit, and technicians subcontracted to monitor and control the AC equipment attend the liaison meeting. These meetings provide a venue in which to share information relating to AC across sections.

An estimate of the power-saving effect of shutting the AC off in five of the seven general storerooms during the transitional seasons suggests an approximate cost savings between three and four million JPY (an almost 30% savings for the general storerooms overall) (Sonoda et al. 2017).

3.2 Shifting to LED Lighting in the Exhibition Galleries

In the summer of 2015, Minpaku decided to switch to LED-based lighting in its exhibition galleries. While the number of examples of the introduction of LED lights for exhibition lighting has increased, no clear guidelines yet exist for the use of LED lighting in museums, with the result that selection criteria present a challenge. Museum lighting needs to be considered in terms of both the display aspect, pertaining to how we want the exhibits to be seen, and the conservation aspect to avoid any negative impact on the exhibits. Therefore, we conducted lighting experiments to measure the optical characteristics under similar conditions for 25 commercial products available on the market in the summer of 2015 to evaluate how "objects" would be visually observed, at which time we clarified the performance of LED lighting. The results are summarized below (Sonoda et al. 2016):

- The survey considered LEDs using two types of excitation source, namely, blue and violet LEDs. In the spectral distribution of blue light excitation LEDs, a peak is observed around the 450 nm wavelength that produces blue LED light. In the spectral distribution of violet light excitation LEDs, wavelengths appear slightly more intense around the 450 nm (blue), 540 nm (green), and 630 nm (red) levels. Based on the spectral distribution, it was confirmed that neither type included wavelengths in the ultraviolet or infrared range (Figure 6).
- A reported disadvantage of LED lighting is that they have poor color-rendering properties. That is, even for "objects" of the same color, the color's appearance will change depending on the illuminating light source. This is referred to as the light source's "color-rendering" property; lighting that produces a color that looks the same as it does when observed under sunlight is regarded as having good color-rendering properties. Figure 7 shows radar charts of color-rendering index values for LED lights R1 to R8 (which represent generally occurring colors) and the special color-rendering index values for R9 (red), R10 (yellow), R11 (green), R12 (blue), R13 (skin color, light), R14 (tree-leaf), and R15 (skin color, medium). The closer the values are to the outer frame of the circle (100), the better the color-rendering property of the light source. We ascertained that LED lights with high color-rendering properties comparable to the color-rendering properties of halogen lamps were available on the market.
- Color temperature, as a quantitative numerical value indicating the color of light, is expressed in units called Kelvins (K). High color temperatures (pale bluish

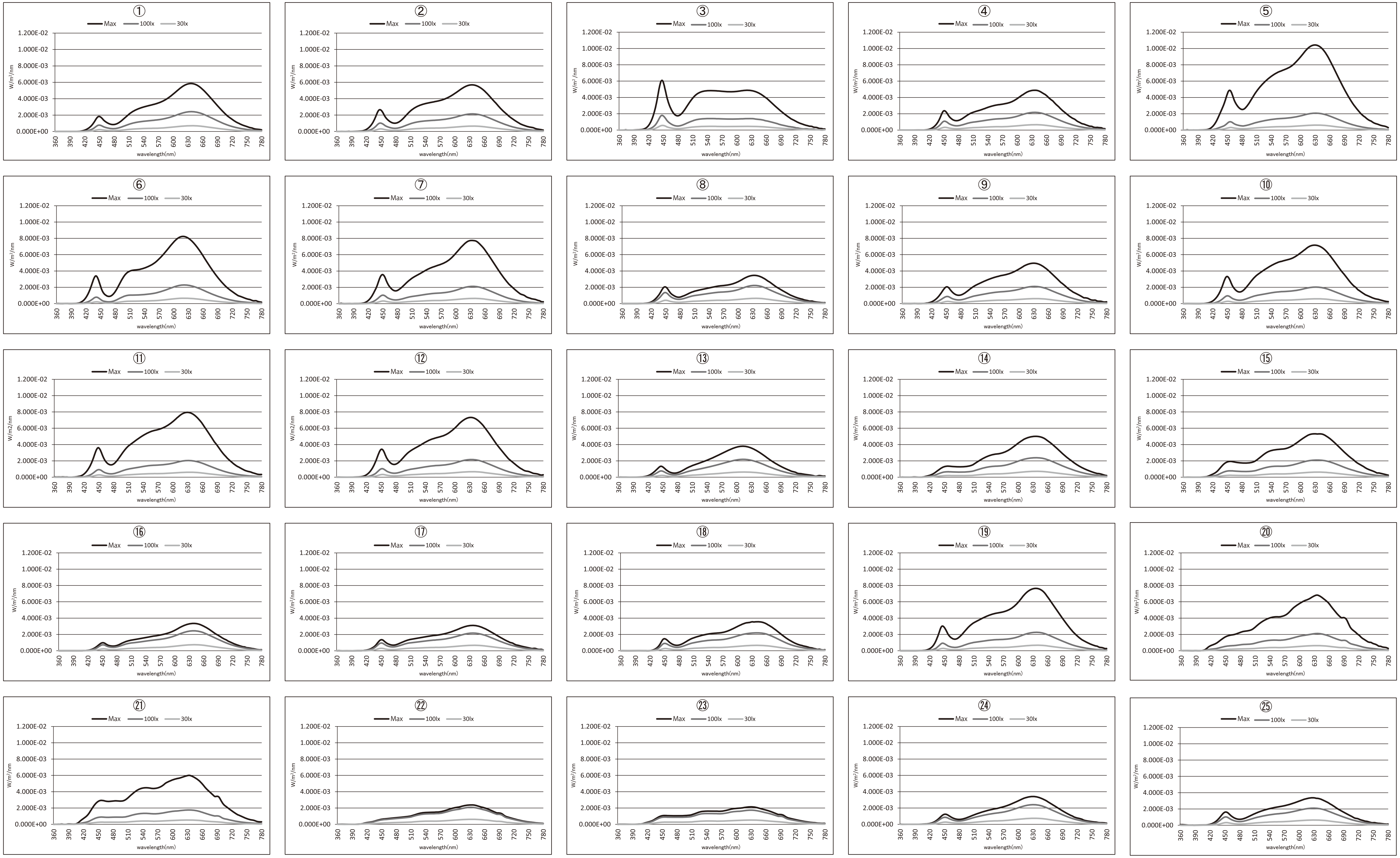

Figure 6 Spectral distribution of LED illumination (maximum illuminance, 100 lx, 30 lx) measured with a CL-500A illuminance spectrophotometer (Konica Minolta) (Source: Sonoda et al. 2016)

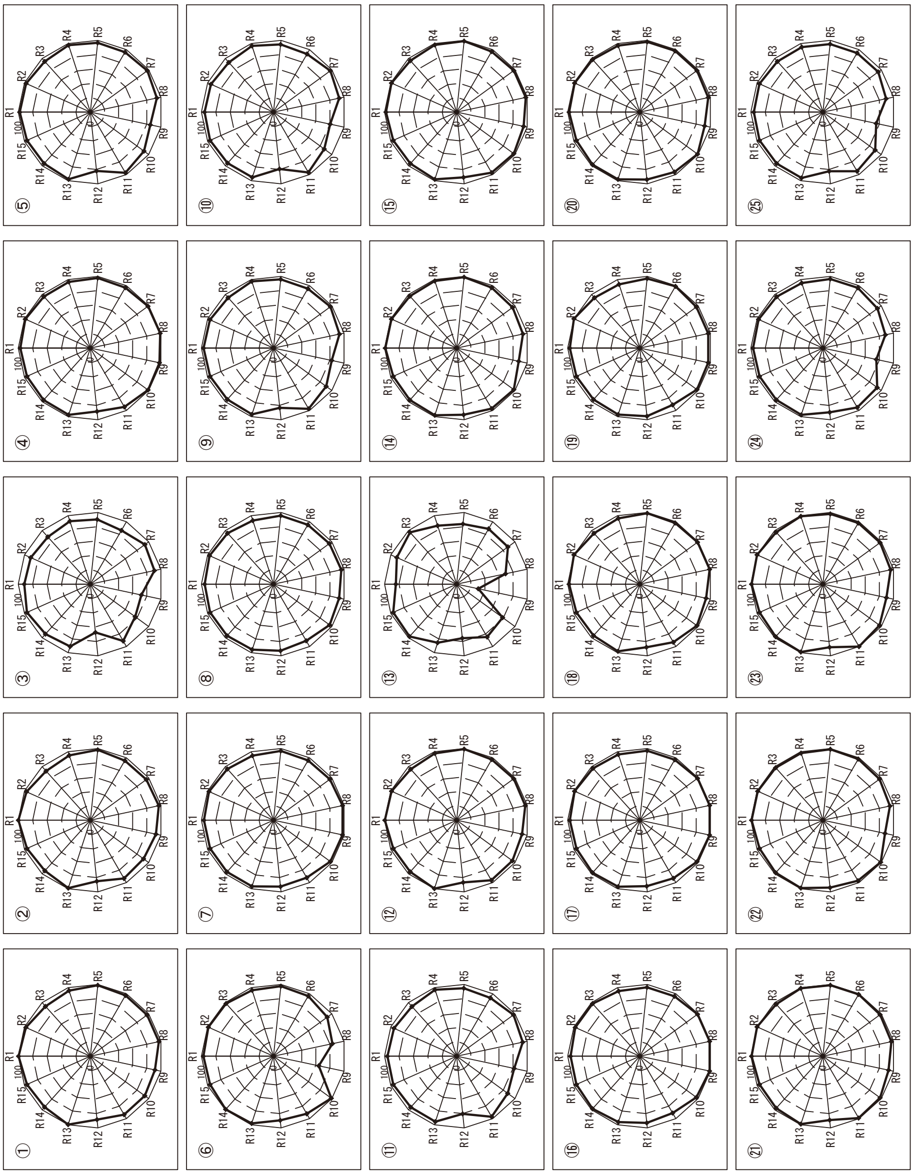

Figure 7 Color-rendering properties of LED lighting: Radar charts for measured values R1 to R15 (100 1x) measured with a CL-500A illuminance spectrophotometer (Konica Minolta) (Source: Sonoda et al. 2016)

white) leave a cool, refreshing impression, while low color temperatures (characterized by reddishness) create a warm, calming atmosphere. The LED lighting considered by the survey, for the most part, featured 3,000 K. However, it was the consensus of the museum staff who witnessed the experiment that, when we assume the display of ethnographic objects, the most preferable option would be a combination of 2,700 K and 3,000 K or an adjustable type that would allow the color temperature to be modified.

- All models considered in the survey were equipped with dimmers. In addition, highly efficient products such as color temperature-adjustable models and models allowing remote control were coming onto the market, and the range of choices for use in museums was expanding.

At Minpaku, taking the results of this experiment into consideration alongside the technical requirements of conventional halogen lamps, we formulated a new basic policy for choosing LED spot lighting for our exhibition galleries and completed the transition to LED lighting in all exhibition galleries in FY2015.

Figure 8 shows a comparison of monthly energy usage for lighting from FY2014 to FY2016. The shift to LED-based exhibition gallery lighting began in February 2016 (marked with an arrow), with all of the lighting in the museum's exhibition galleries converted to LED lighting by the following month. In the same year, the lighting in administrative offices and research departments was also converted to LED-based lighting with the result that the amount of power used for lighting was reduced to about 60% of

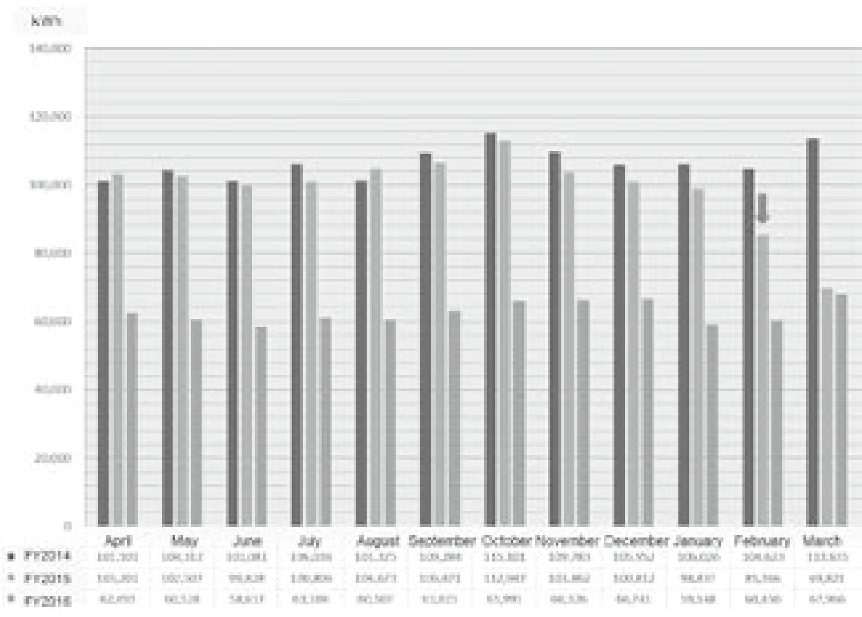

Figure 8 Comparison of lighting power usage (FYs2014, 2015, 2016)
(Source: Facilities Unit of the Finance Section, Office of Administration, Minpaku)

the previous levels. This had the effect of reducing expenditures by approximately ten million yen per annum. At Minpaku, non-LED lighting is still used in the library and in some storerooms; this will gradually be phased out in favor of LED lighting.

4. Conclusion

Sustainable museum environment is a major challenge in the field of conservation. In 2014, the International Institute for Conservation of Historic and Artistic Works (IIC) and the International Council of Museums - Committee for Conservation (ICOM-CC) issued a declaration on environmental guidelines (Bickersteth 2016) and recommended the reduction of energy usage and the introduction of alternative energy sources in museums and other institutions that handle similar collections. In order to mitigate climate change, carbon emissions should be reduced, and energy-conscious solutions should be considered, such as incorporating simple, easily maintained techniques into collection management techniques that do not assume the use of AC. Moreover, they did not consider it necessary that environmental control for borrowed objects and environmental control focusing on objects held in museums' own collections should be the same.

Some examples of existing guidelines are summarized below:

- The Bizot Group,[6)] which consists of the directors of some of the world's largest museums and art galleries, many in France, stipulates that for objects containing hygroscopic material such as canvas paintings, textiles, or ethnographic objects, a stable RH is required in the range of 40–60% and a stable temperature in the range of 16–25°C with fluctuations of no more than ±10% RH per 24 hours within this range. However, more sensitive objects will require more rigorous RH control depending on the materials, condition, and history of the object itself.
- In Australian Institute for Conservation of Cultural Material (AICCM) Guidelines for Australian Cultural Heritage Collections,[7)] it is recommended that temperature remains between 15 and 25°C with allowable fluctuations of 4°C per 24 hours, and that RH remain within the set-ranges of 45−55% (temperate climate) and 50−60% (subtropical or tropical climate) with allowable fluctuations of ±5% per 24 hours.
- At the American Institute for Conservation (AIC),[8)] a set point in the range of 45–55% RH with an allowable drift of ±5%, yielding a total annual range of 40% minimum to 60% maximum is acceptable, while temperatures are acceptable between 59 and 77°F.

The 2014 declaration by the IIC and ICOM-CC demonstrates value as a joint initiative by two groups of conservation experts engaging with a new understanding of the issues facing conservation environments. However, this does not necessarily indicate the presence of any unified perspective in the conservation field, and we are left with the recognition that further research will be necessary in the future.

Given this premise, it will be important to verify reliable facts and data regarding the actual temperature and RH conditions that prevail in exhibition galleries and storerooms as well as how collected objects are being conserved in Japanese museums, which face different climatic conditions than their Western counterparts, and to disseminate the results of such research in Japan and overseas. I hope that this paper might serve as a part of that project. Only with the accumulation of a substantial body of such research will we finally be able to demonstrate safe display and storage conditions for objects that give due consideration to Japanese or other climatic conditions. These results will lead to an environmentally conscious, economical, future-oriented, and sustainable vision for collection management and environmental control.

Notes

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