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Developing a Maintenance Plan for the Stone Sculptures and Decorative Elements in the Gardens of the National Palace of Queluz, Portugal.

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Abstract

The Gardens of the National Palace of Queluz in Portugal were laid out in the 18th century. Over two hundred stone elements, mostly marble and limestone, decorate the fifteen hectare grounds. The location of these stone elements in a garden environment which provides shade and with relatively high humidity fosters their biocolonization. Growth of micro-organisms, lichens and mosses, contributes to the deterioration of the stone and, in some cases, disfigures the sculptural elements. While regular cleaning will solve this problem, if frequently repeated over centuries, it also will contribute to the deterioration of the stone sculptures. Based on the fact that the action of biocides is not instantaneous but requires some time to act on these organisms, a minimum maintenance plan is being developed. This maintenance plan takes into account the present reduced maintenance personnel at the Palace and fulfils the objective of complying with the minimum intervention criteria. The aim is to have all sculptures attain a uniform appearance, in harmony with the age of the gardens.

Keywords: Biological colonization, biocolonization control, maintenance plan, marble sculpture, limestone decorative elements, minimum intervention, biocides

Zur Aufstellung eines Planes für den Unterhalt der Steinskulpturen und der dekorativen Elemente in den Gärten des Nationalpalastes von Queluz, Portugal

Zusammenfassung

Die Gärten des Nationalpalastes von Queluz in Portugal wurden im 18. Jahrhundert angelegt. Mehr als zweihundert Figuren aus Naturstein, in der Hauptsache Marmor und Kalkstein, schmücken das fünfzehn Hektar große Gelände. Die Lage dieser Figuren aus Naturstein in einem Garten, der Schatten spendet und in dem eine vergleichsweise hohe Feuchtigkeit herrscht, begünstigt organischen Bewuchs. Das Wachstum von Mikroorganismen, Flechten und Moose, trägt zur Zerstörung des Natursteins bei und entstellt in einigen Fällen die Figuren. Regelmäßiges Reinigen, wenn es Jahrhunderte lang oft wiederholt würde, könnte das Problem lösen, aber es würde auch zur Zerstörung der Figuren beitragen. Die Wirkung von Bioziden ist nicht unmittelbar, bei den vorliegenden Organismen ist vielmehr einige Zeit notwendig. Dies wurde bei der Erstellung eines Planes für einen minimalen Unterhalt berücksichtigt. Der Unterhaltsplan trägt auch dem derzeitigen verringerten Personalstand der Verwaltung des Palastes Rechnung und wird der Zielvorstellung eines minimalen Eingriffes gerecht. Es wird angestrebt, dass alle Skulpturen gleichmäßiges Aussehen erhalten und Harmonie mit dem Alter des Gartens hergestellt wird.

Stichwörter: *Biologischer Bewuchs, Unterhaltsplan, Marmorskulpturen, Dekorative Kalksteinfiguren, Minimale Intervention, Biozide.*

1 Introduction

The National Palace of Queluz is located some 12 km west of Lisbon, half way to Sintra. This Baroque Palace and its gardens have been compared to Versailles, though their style is uniquely Portuguese. Currently it is a museum while also serving to host prominent guests of the Portuguese Government.

The original buildings, later transformed into the present Palace, belonged to a private country estate which was confiscated by the crown when Portuguese independence was restored in 1640. The property was assigned to the princes of the Royal Family. It was first occupied by D. Pedro, later reigning as D. Pedro II (1683-1706) who introduced some minor changes to the building, but the first major alterations which transformed this summer house into the initial nucleus of the present palace were carried out by the son of D. João V (1707-1750), D. Pedro, between 1747 and 1758. In 1760, upon his marriage to D. Maria, later D. Maria I (1777- 1816), the second construction phase of the palace began under the direction of the French architect Jean Baptiste Robillion. The new wing, called after the architect, serves to link the original nucleus to the gardens via the Lions' Stair was completed by 1786. Then the last construction phase began with the addition of what is called the Pavilion of D. Maria I, currently used to house government guests, which was completed by 1792.

The formal gardens, called the Malta garden and the Hanging garden, in typical French style, are decorated with statues; some in marble and some cast in lead; balustrades; fountains, and glazed ceramic vases, as well as Portuguese azulejos, which also line the canal where the creek that runs through the gardens flows.

The larger part of the fifteen hectare grounds are a park traversed by various straight paths, the major ones radiating out from the main gate of the Hanging Garden. The park is also decorated with various fountains as well as an impressive cascade at the other end of the path that runs straight from the main gate.

2 The Conservation/Restoration Project

Given the size and complexity of the Gardens of the National Palace of Queluz, the project is subdivided into different subprojects that address specific parts of it. Thus, the restoration of the gardens and the needed improvements to the hydraulic system required to address the watering needs of the garden as well as that of the fountains and cascades, is being addressed by the Portuguese Institute for Architectural Heritage (IPPAR). The restoration of the lead sculptures in the garden, cast by the English sculptor John Cheere, has been taken over by WMF-Britain. WMF-Portugal is undertaking the conservation of the stone sculptures as well as that of the Canal dos Azulejos. The present paper will discuss only the approach that was developed to address the conservation of the decorative stone elements in the gardens. As described below, these do not include the fountains and cascade because these elements require a formal conservation intervention.

As in previous projects, such as the conservation of the Cloister from the Jeronimos Monastery and that of the Tower of Belem, the financial cost of the project is divided between IPPAR, World Monuments Fund and its Portuguese affiliate, WMF-P, responsible for coordination of the project.

3 Rationale for the Approach

The gardens at the National Palace of Queluz are decorated with 91 marble statues and 35 marble busts, apart from 40 bases, 143 pedestals, 100 vases and 43 balustrades sections, carved some in marble and mostly in limestone as well as 22 marble fountains and a large limestone cascade.

Stone elements in an outdoor environment, particularly in a garden with fountains and a stream flowing through it, will tend to be colonized by biological organisms such as algae, mosses and lichens. The latter can be disfiguring and, therefore, the statues and other stone elements have been periodically, albeit not systematically, submitted to cleaning. Given the number of stone elements, these efforts have mainly been carried out on those statues in the gardens next to the Palace such as the garden of Malta. Since the cleanings have been carried out at different times and by different enterprises, the degree of cleaning obtained varied significantly resulting in a juxtaposition of statues that retain an immaculate white color with others that are somewhat colonized or partly covered with lichens as shown in Figure 1. Statues in shaded park areas show a far higher degree of biocolonization, as shown in Figure 2. Thus, there is no coherence in the presentation of these decorative elements, and their value as well as that of the whole garden is diminished by this fact, while the actual stone elements are threatened by the corrosion induced from the growth of these microorganisms [1, 2, 3].

Figure 1: Three sculptures in the Garden of Malta. Left: cleaned in 2003; center: cleaned in 1999; and, right: cleaned in 1997

Figure 2: Two statues in the park area of the garden. Note the heavy lichen colonization that cover them totally.

Considering that thorough cleanings of the stone elements, as has been the customary albeit sporadic approach in the past, will eventually erode the surface of these decorative elements, and taking into account not only the limited amount of funds available for regular maintenance but also the restricted number of maintenance personnel in the Palace staff, a new approach for the conservation — not restoration — of these stone elements, was devised. This is based on the need to raise the awareness of the people, including conservators, that in a garden environment, the stone elements need not be spot-

less clean. On the contrary, a limited amount of biocolonization gives the garden an aged appearance, in harmony with the buildings and other decorative elements in the Palace. Thus, a minimum intervention approach had to be developed. The objective of the intervention was to keep the statues free of the most invasive biocolonization while not trying to restore them to their original appearance. This approach would serve to avoid the present situation where immaculately white statues are next to others completely disfigured by lichen colonization. The ultimate objective is to determine the minimum regular maintenance required to maintain a uniform appearance between all stone elements. For this purpose, workshops were developed to train conservators and palace staff in this approach.

This approach cannot be used for the fountains and the cascade, since the complexity of their structure requires a formal conservation intervention. This is in particular valid for the six fountains that have a mixture of stone elements and lead sculptures.

4 Preliminary Testing

The methodology adopted makes use of the fact that biocides require a certain amount of time to be completely effective, depending on the type and concentration of the biocide applied and the nature and vegetative state of the colonizing species. Since these stone elements are in a garden, there was a concern about application of high concentrations of a biocide. Thus, low concentrations were tested. Two biocides were selected for testing: one based on a quaternary ammonium salt, a product that has proved to be effective yet relatively safe for human beings but that has not a long residual action; and, the second one was a zinc chloride solution. This was a test trail to determine its effect as a biocide based on the effectiveness of zinc metal strips as a fungistat [4].

For the quaternary ammonium salt, the biocide Preventol R80 (hereafter Preventol), produced by Bayer, was used in concentrations ranging between 1.5 % and 3 % by volume. The same concentration range, now in weight by volume, was used for the zinc chloride ($ZnCl_2$) solutions. To measure the presence of active biological colonization due to autotrophic species, a portable fluorimeter was used [5]. Readings were taken at the area of interest, first dry, and then after wetting. A decrease in the ratio of these readings indicates diminishing biological activity while values close to 1 correspond to dead organisms.

The results of this study, which focused on the recolonization rate [6], show that for clean sculptures, located near to fountains or vegetation, recolonization occurs in about three years, while it takes about seven years for objects located in highly exposed locations such as terraces, even if these are facing the garden. Water repellents slightly retard but negatively interfere with recolonization making them inappropriate for this use. The most important factor influencing the rate of recolonization is the environment in which the object is located. These findings are applicable to marble sculptures since only these were monitored in the study.

Table 1: Ratio of wet/dry fluorimeter intensity readings for the two biocides tested at two concentrations after one single application on different biological growths.

		Conc.	Preventol	$ZnCl_2$
White lichens	Before	1.5	2.5	6
	After 9 months		2.5	3.8
	Before	3	6.8	6
	After 9 months		1	3
Orange lichens	Before	1.5	4.5	4.2
	After 9 months		2.9	2.1
	Before	3	4.4	4.8
	After 9 months		0.9	1.5
Gray diffuse biocolonization	Before	1.5	6	5.4
	After 9 months		1.9	1.7
	Before	3	7.8	8.1
	After 9 months		1.2	1.2

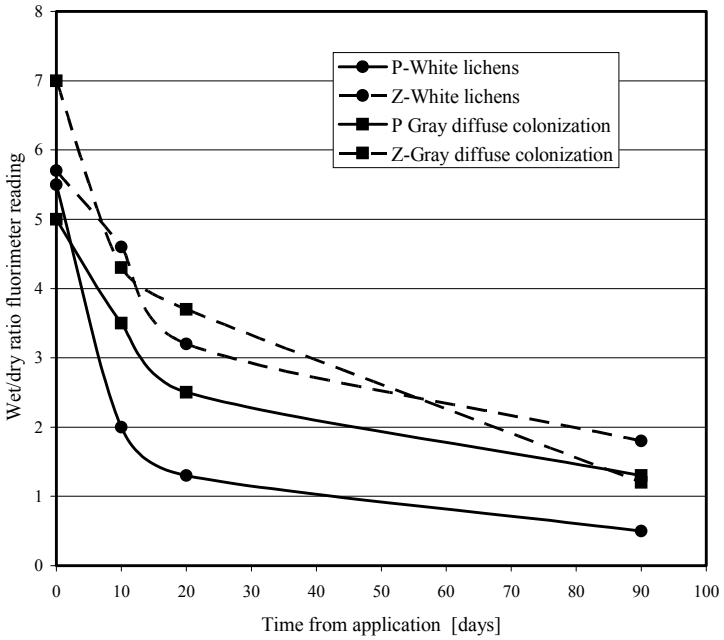

Figure 3: The wet/dry ratio of the fluorimeter readings for three successive applications of biocide solutions at 1.5 % concentrations for the case of white lichens and gray diffuse colonization. Key: P indicates Preventol, Z indicates zinc chloride solution

Figure 4: Detail of the area of the pedestal where the left half was treated with a 2 % Preventol solution and the right half with the 2 % zinc chloride solution. Only one application was used. The stone has been wetted for the measurements and this highlights the active bio-colonization which tends to look greener when wet.

During the testing carried out it was shown, as expected, that the higher the concentration of the biocide, the more effective the reduction of biological activity, Preventol being more effective for various types of lichens and the general grayish diffuse colonization than the zinc solutions. But even at the lowest concentration, 1.5 % w/v the zinc solution proved effective for the general gray diffuse colonization after 9 months.

Repeated applications at approximately ten days intervals accelerated the process for both agents, and, for the case of zinc solutions, it improved its action on some of the lichens. Some of the data obtained for 3 applications of the biocides at the 1.5 % concentration are shown below in Figure 3. The applications were always done after taking a reading. Thus, the short term effectiveness of the first two applications can be evaluated.

Figure 4 shows the results obtained during test applications to some pedestals in the park area of the garden.

5 Methodology

5.1 Introduction

Preliminary tests showed that a single application of Preventol at a 1.5 % concentration, far lower than normally used in regular conservation practice, was sufficient to effectively eradicate most of the micro-organisms in about nine months. The white lichens proved to be highly resistant to this treatment, however, as they are colonizing white marble and lime-

stone they are visually less disturbing. This is an important point since environmental contamination is a concern given that the objects to be treated are located in a garden where plants could be negatively affected by eventual residual run off of the biocides. Since the objective is to develop a regular maintenance plan, it is important to reduce to a minimum the use of biocides.

As the quaternary ammonium biocide is more effective than the zinc chloride solution which acts mainly as a fungistat, it was decided that two successive applications were to be made. First, the Preventol solution was applied and, six months later, the zinc solution. Given the concern of introducing chlorides into the stone by the use of zinc chloride, two alternatives were tested: a solution of zinc naphthenate, which had been experimented with in the past [7] and a zinc acetate solution, considering that the acetate is likely to be biodegradable.

Since the 1.5 % $ZnCl_2$ solution contains about 1 % w/v of elemental zinc, both the above alternative products were diluted to this concentration. The zinc naphthenate is commercially available in a solution which contains approximately 10 % Zn, a 1 in 10 dilution in acetone was prepared to obtain the 1 % Zn content. For the case of the zinc acetate solution was prepared using either a 2.8 % solution if using the anhydrous salt or a 3.4 % solution if the dehydrate salt ($Zn(C_2H_3O_2)_2.2H_2O$) is used.

It is important to mention, a point that was not described in the French study, that the zinc naphthenate has an extremely persistent and unpleasant smell. Six months after application, the smell could still be perceived at close range. Hence, this product was only applied once on two pedestals.

5.2 The Workshops

The three day workshops are scheduled every six months, in spring and in autumn. Participants to the workshops are conservation students or professionals in the field interested in the topic. The mornings serve to give a brief introduction to the problem and the approach used to address it. The lectures also provide information about the stones used for the carving of these elements, their deterioration through biocolonization and the methods available for its removal. The importance of regular monitoring and upkeep are highlighted, since these are the points that will allow accomplishing the desired objective of conservation with a minimum intervention.

During the afternoons, the participants first document the stone elements they have been assigned to work on. Then, they learn how to prepare the biocide solution that is to be used. Prior to the application of the biocide (1.5 % v/v Preventol), the stone element is softly brushed to remove any surface dust, cobwebs and lose debris that may be present. Finally, the biocide is applied by brushing. Six months later, these elements are brushed clean, sometimes with the aid of water, to eliminate any remains of the defunct biocolonization although accepting that their reaction imprints on the stone surface remain visible. Then the zinc acetate solution is applied. The process is repeated with the documentation and application of the biocide on a new set of elements.

It is important that cleaning be kept to a minimum serving only to eliminate the loose bio-remains that could interfere with the correct application of the second biocide. This approach is important for two reasons. In the first place it eliminates any accidental damage that could occur during this action; and, in the second, experience has shown that when biocides are effective over a relatively long time, the surface acquires a natural and "perfectly" clean appearance by itself.

Four workshops have been held so far (autumn 2005, spring and autumn 2006, spring 2007) and it is foreseen to continue this timetable. On average, six to eight participants take part, with at least two of them being staff of the Palace. So far, 15 pedestals, 16 bases, 15 statues, 21 vases and 13 balustrade sections have been treated.

Among the objectives of the workshop is to find out what is the rate of recolonization, which may be different for statues in different areas in the garden, so as to establish the frequency of biocide application needed to keep these decorative stone elements in their best appearance while minimizing their maintenance. This approach can be used for the majority of the stone elements in the garden but cannot be used for the fountains and the sculptures in them.

6 Results obtained

Since spring of 2005, when a set of 6 pedestals was treated with the biocide (1.5 % Preventol) in preparation for the first workshop, the established schedule has been maintained and regular monitoring of the treated objects has been carried out.

5a

5b

5 c

Figure 5: Section of the balustrade exemplifying the results of the applied treatments. (a) Before (spring 2006); (b) Fall 2006, five months after application of Preventol 3 % solution; (c) March 2007, six months after application of the zinc acetate solution (1 % Zn).

Figure 6: The putti group on the left—photographed in April 2006—was treated with the biocide in September 2006 and is shown on the right in May 2007.

Figure 7: View of one of the balustrades in May 2007. The left side was treated in fall 2006. The cleaner appearance of the balusters on the left side is clearly noticeable in comparison to those on the right.

The results have been very promising, with no recolonization occurring to date. Even elements located in a very shady and damp areas, such as a balustrade, composed of 4 L-shaped sections, which encloses a small fountain and a lead sculpture on a pedestal, has as yet not recolonized after one year, in spite of the very rainy spring (in 2007).

This balustrade was one of the elements that was most heavily colonized by various kinds of lichens, as shown for one of its sections in Figure 5a. Hence, it was decided that rather than using the 1.5 % concentration solution of the biocide, for this special case a 3 % solution was applied in April 2006. By September 2006, when the zinc solution at the 1 % elemental zinc concentration was applied, most of the biocolonization had disappeared as shown in Figure 5b. This decreased even more in the following months as shown Figure 5c.

Similar results were obtained for other objects. Figure 6 shows the before and after of another pair of putti. Figure 7 shows one of the balustrades where half had been treated with the biocide. At this point the second half has already been treated.

7 Conclusions

After two years of the first biocide application, no recolonization has been observed, even for areas that are in shady and damp areas. While the project is ongoing, the information gathered so far indicates that this approach to maintenance reduces significantly the cost of periodic cleaning plus having the advantage of minimizing the intervention on the stone objects. This important point has long been recognized and summarily expressed as the "minimum intervention" criterion.

The practical work carried out so far has allowed estimating the time required for the actual application of the biocide. For example, three persons can dry-brush and apply the biocide solution to a 20-m balustrade and the 3 statues and 3 vases in three hours. So far, an average of 6 persons working for 36 hours (approximately 5 days) treated 40 % of the bases, 12 % of the pedestals, 16 % of the statues, 21 % vases and 30 % of the balustrades. Thus, one can estimate that it would take three months for two persons working regularly to apply the biocide to all the decorative stone elements in the garden. Considering that the rate of biocolonization is relatively slow, this means that the maintenance work can be spread out over a period of at least two years to maintain these stone elements clean with what can really be called a minimum intervention.

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