HERITAGE 2018

Proceedings of the 6th International Conference on Heritage and Sustainable Development

10th Anniversary Edition

VOLUME 2

Edited by

Rogério Amoêda
Sérgio Lira
Cristina Pinheiro
Juan M. Santiago Zaragoza
Julio Calvo Serrano
Fabián García Carrillo

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In Memoriam
Professor Gregory Ashworth

(1941-2016)

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Granada, Spain
12-15 June

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Green Lines Institute for Sustainable Development
Av. Alcaides de Faria, 377 S.12
4750-106 Barcelos, Portugal
mail@greenlines-institute.org
http://www.greenlines-institute.org

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Foreword

Heritage 2018 - 6th International Conference on Heritage and Sustainable Development celebrates the 10th anniversary of Heritage Conferences. As the previous editions *HERITAGE 2018* aimed at maintaining a state of the art event regarding the relationships between forms and kinds of heritage and the framework of sustainable development concepts, namely the framework of the 2030 Agenda for Sustainable Development.

However, the four dimensions of sustainable development (environment, economics, society and culture) are, as in the past, the pillars of this event defining an approach on how to deal with the specific subject of heritage sustainability. Furthermore, beyond the traditional aspects of heritage preservation and safeguarding the relevance and significance of the sustainable development concept was to be discussed and scrutinised by some of the most eminent worldwide experts.

For a long time now, heritage is no longer considered as a mere memory or a cultural reference, or even a place or an object. As the previous editions of "Heritage" (2008, 2010, 2012, 2014 and 2016) have proven, heritage is moving towards broader and wider scenarios, where it often becomes the driven forces for commerce, business, leisure and politics. The Proceedings of the previous editions of this conference are the "living" proof of this trend.

As stated by some the Sustainable Development Goals of the 2030 Agenda, the role of cultural and social issues keeps enlarging the statement where environment and economics had initial the main role. The environmentalist approach (conceiving the world as an ecological system) enhanced the idea of a globalised world, where different geographic dimensions of actions, both local and global, emerged as the main relationships between producers, consumers and cultural specificities of peoples, philosophies and religions. In such a global context heritage became one of the key aspects for the enlargement of sustainable development concepts. Heritage is often seen through its cultural definition and no further discussion seams to be appropriate. However, sustainable development brings heritage concepts to another dimension, as it establishes profound relationships with economics, environment, and social aspects.

Nowadays, heritage preservation and safeguarding is constantly facing new and complex problems. Degradation of Heritage sites is not any more just a result of materials ageing or environmental actions. Factors such as global and local pollution, climate change, poverty, religion, tourism, commodification, ideologies and war (among others) are now in the cutting edge for the emerging of new approaches, concerns and visions about heritage. Recent events in the Middle-East and other parts of the World are saddling proving the rightness of these assertions and deserve our attention.

Thus, *HERITAGE 2018 - 6th International Conference on Heritage and Sustainable Development* proposed a global view on how heritage is being contextualised in relation with the four dimensions of sustainable development. What is being done in terms of research, future directions, methodologies, working tools and other significant aspects of both theoretical and fieldwork approaches were the aims of this International Conference. Furthermore, heritage governance, and education were brought into discussion as key factors for enlightenment of future global strategies for heritage preservation and safeguarding.

A special chapter on Preservation of Muslim heritage was included in this edition because of its singular and utmost significance and because the Venue of this edition was the city of Granada, one of the most extraordinary places to understand and feel the merging of cultures, arts and traditions. When religious and cultural issues are raising significant misunderstandings Heritage 2018 aimed at contributing to a valid, peaceful and fruitful discussion under the broad umbrella of sustainable development goals.

Authors submitting papers to Heritage 2018 were encouraged to address one of the topics of the Conference by providing evidence on past experience and ongoing research work. As a result, Heritage 2018 welcomed a significant number of papers and presentations addressing field work and case studies but also theoretical approaches on a diversity of thematic. As in the previous editions Early Stage Researchers were welcome to share the results of their research projects, namely post-graduation projects and doctoral projects, among others.

The Organising Committee also expresses its gratitude to all Members of the Scientific Committee who reviewed the papers and made suggestions that improved the quality of individual work and the over-all quality of the event.

The editors would like to express their gratefulness to all the partners and sponsors of this edition of Heritage who joined the effort to make a significant Conference. Our special word or recognition to the University of Granada that joined efforts with Green Lines Institute to make this event. Also to the Municipality of Granada, to the Bureau of Tourism of Granada and to the Council of the Alhambra and Generalife our recognition for their participation.

The Editors

Rogério Amoêda
Sérgio Lira
Cristina Pinheiro
Juan M. Santiago Zaragoza
Julio Calvo Serrano
Fabián García Carrillo

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Chromatic alterations by microalgae at National Mall fountains in Washington D. C. (USA)

F. C. Bolívar-Galiano & C. Abad-Ruiz
Department of Painting, University of Granada, Granada, Spain

A. Yebra
Department of Painting, University of Seville, Seville, Spain

J. Romero-Noguera
Department of Painting, University of Granada, Granada, Spain

P. Sánchez-Castillo
Department of Botany, University of Granada,Granada, Spain

ABSTRACT: The National Mall is the great promenade that connects the most important buildings of the capital of the United States: the capitol with the George Washington and Abraham Lincoln Memorials touring the Castle and the main Smithsonian museums and the National Gallery of Art. The fountains present inside and outside these museums suffer alterations of color and texture due to colonization of algal populations on the surface of their constituent materials. We have studied 9 fountain belonging to the National Gallery of Art, the Smithsonian National Museum of African American History and Culture, the Smithsonian Museum of Contemporary Art (Hirshhorn), the Smithsonian Arts and Industries Building, the Smithsonian Institution Building (the Castle), the Smithsonian National Museum of American History and the Smithsonian National Museum of the American Indian. In this work carried out by the national Project VIRARTE (UGR-MEC) at the Smithsonian Museum Conservation Institute (MCI-SI), the relationship between the diversity of the algal groups and the material composition and typology of the fountains is studied. We have studied the presence of different species of green microalgae, blue-green microalgae and diatoms that form pustules, films, mats and mineral crusts on fountains constructed with granite, limestone and various metals, and even upon sealant resins that are used to repair water leaks. The ultimate goal of this work in the control of these formations to avoid the aesthetic, functional and material damage that these photosynthetic organisms produce in the architectural heritage associated with water.

1 INTRODUCTION

The National Mall of the United States is a National Park located in Washington D. C. that contains a number of museums of the Smithsonian Institution, art galleries, cultural institutions, and various memorials, statues and sculptures. All the fountains associated to the gardens and buildings of the Mall are affected by microalgal colonization. Microalgae are one of the most important biodeterioration agents of ornamental fountains and architectural heritage associated with water in general. They deteriorate stone and other materials such as metal over time and cause a number of chromatic, physical and chemical alterations that produce aesthetic, functional and material damage.

In this work, we have studied microalgal colonization and the relationship between different types of algae and the chromatic alterations they produce in 9 fountains. All the studied fountains belong to relevant buildings of the Mall: the National Gallery of Art, the Smithsonian National Museum of African American History and Culture, the Smithsonian Museum of Contemporary Art (Hirshhorn), the Smithsonian Arts and Industries Building, the Smithsonian Institution Building (the Castle), the Smithsonian National Museum of American History and the Smithsonian National Museum of the American Indian.

The National Museum of African American History and Culture is devoted to the documentation of African American life, history, and culture. It was established by Act of Congress in 2003 and opened to the public in 2016 as the 19th and newest museum of the Smithsonian Institution. To date, the Museum has collected more than 36,000 artifacts. In this building, we took samples from the outside pool.

The Hirshhorn Museum opened to the public in 1974 and has since then exhibited a large collection of modern and contemporary art which is constantly growing. The studied fountain is located in the center of the Plaza of the Hirshhorn, outside the Museum Lobby in the main level of the building (Fig. 1a).

The Smithsonian Institution Building, popularly known as the "Castle", was built in 1855 and it was the first Smithsonian building. Today, this building houses the Institution's administrative offices and the Smithsonian Information Center. The Arts and Industries Building, located next to the Castle, was opened in 1881. Throughout its history, this building has housed a number of different collections and has been used for several purposes, and at the present moment is undergoing renovation. We studied two fountains from this area, both located in the Smithsonian Gardens. The first one is the Large Acanthus Fountain (Fig. 1b), placed in the Mary Livingston Ripley Garden, on the eastern border of the Arts and Industries Building. This fountain was constructed around 1850. The second is the Keith Fountain, located in the Kathrine Dulin Folger Rose Garden, right in front of the same building and to the east of the Smithsonian Castle. This fountain was constructed in the late 1800's.

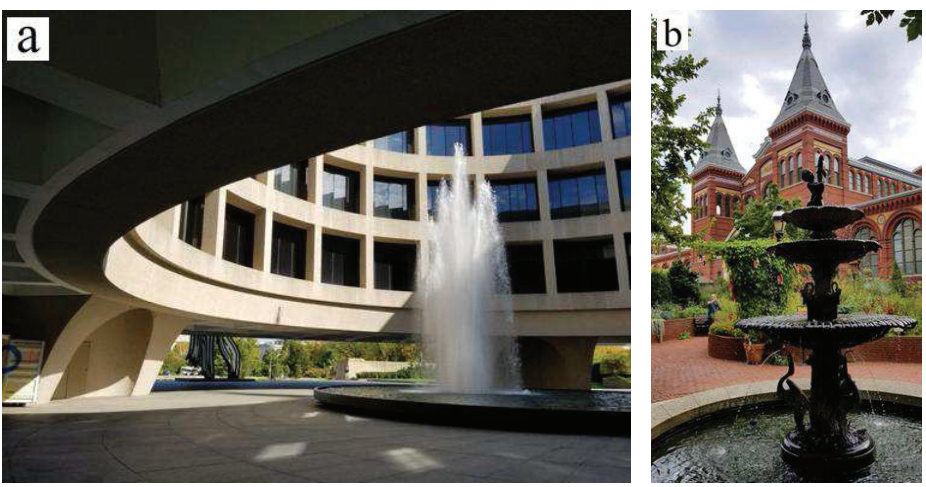

Figure 1. Smithsonian fountains. a) Hirshhorn fountain (II) b) Large Acanthus Fountain (III).

The National Museum of American History opened to the public in 1964 as the sixth Smithsonian building on the National Mall in Washington. Its basic mission is the collection, care and study of objects that reflect the experience of the American people. Currently it collects and preserves more than 3 million artifacts which comprise the greatest single collection of American history. In this building, we took samples from the pool located in front of the northern facade.

The National Museum of the American Indian houses one of the world's largest and most diverse collections of Native American arts and artifacts, which represents over 12,000 years of history and more than 1,200 indigenous cultures throughout the Americas. The building located

on the National Mall was opened in 2004, and offers exhibition galleries and spaces for performances, lectures and symposia, research, and education. We studied the fountain on the northwest corner of the building.

The National Gallery of Art was dedicated in 1941, with the opening of its West Building. Since then, it has collected a large and world-renowned collection of paintings, sculptures, decorative arts, prints, drawings and photographs. In fact, in 1978 a new building (the East Building) was dedicated in order to exhibit all the collections, which had grown beyond the capacity of the original galleries. We studied three different fountains from the National Gallery of Art: the Girl Water Lilies Fountain, inside the West Building, which was constructed in 1928; the outside fountain that flows into the cafeteria; and the southern fountain located in front of the west façade of the West Building (Fig. 2).

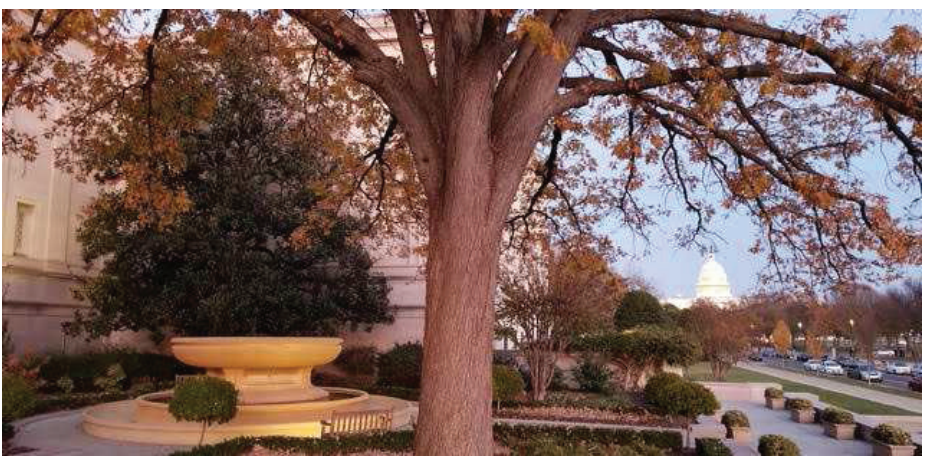

Figure 2. Fountain located in front of the west façade of the West Building of the National Gallery of Art (VIII)

2 MATERIALS AND METHODS

2.1 *Studied material*

We have studied a total of nine fountains and designated them with roman numerals. The studied fountains are the following: I) The outside pool of the National Museum of African American History and Culture, made of grey granite; II) The pool in the plaza of the Hirshhorn Museum, made of bronze; III) The Large Acanthus Fountain, made of cast iron; IV) The Keith Fountain, made of cast iron; V) The pool in front of the National Museum of American History, made of pink granite; VI) The fountain on the northwest corner of the National Museum of the American Indian, made of Golden Sand limestone; VII) The fountain outside the National Gallery, which flows into the cafeteria, made of grey granite; VIII) The fountain located in front of the west façade of the West Building of the National Gallery, made of ochreous limestone; IX) The Girl Water Lilies Fountain, made of bronze and pink marble. We took samples from each fountain to identify the main types of colonizing algae in general. For the study of

chromatic alterations, we focused on one specific area on each fountain. Photographs of those specific areas were taken.

2.2 *Sampling*

With the permission of the competent authorities, representative samples of epilithic microalgae were collected from different areas of our nine fountains using scalpel and pliers between August and December of 2017. The samples were then fixed in a solution of glycerol and glutaraldehyde 25% for their conservation and further examination.

2.3 *Identification of algae*

For the identification of the different algae, all the samples were examined by stereoscopic microscope and optical microscope; the different species were identified using the following keys and taxonomic identification works: Bourrelly (1966), Bourrelly (1970), Komárek and Anagnostidis (1998), Bolívar Galiano and Sánchez Castillo (1999), Wehr (2003), Komárek and Anagnostidis (2005) and Komárek (2013). Each species forming the algal communities were quantified by the assignment of an index (+ - 5) depending on their proportion in the sample. The indexes represent the following percentages in relation to the total: + = 0-1%; 1 = 1-10%; 2 = 10-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-100%.

2.4 *Algal cultures*

The samples were also cultured in solid medium for the growth and identification of certain groups of microalgae. The cultures were elaborated in agar plates with BBM medium for the culture of green algae and BG11 medium for the culture of cyanobacteria. No specific medium was used for the culture of diatoms. We used an agar concentration of 2%.

2.5 *Chromatic diagnosis*

For each fountain, we chose a specific area in which we related the color of the chromatic alteration with the predominant type of algae that produced it. In order to assign the most precise colors to the algal communities, we used the Faber-Castell color range, which has standard numeration for all its pencils and bars. For each tonality, we considered three degrees depending on the intensity of the color: A (lightest), B (intermediate) and C (darkest). We also used the equivalent notations from the Munsell Soil Charts (Munsell, 2000) for each tonality.

3 RESULTS

3.1 *Colonizing microalgae*

We identified the main types of microalgae growing in each studied fountain.

In the fountain from the National Museum of African American History and Culture (I) the main colonizing algae were the green algae *Chlorosarcinopsis* sp, followed by diatoms of the genus *Navicula* and the cyanobateria *Leptolyngbya* sp. No additional species were found in culture.

The most frequent algae in the fountain of the Hirshhorn Museum (II) was the green algae *Oocystis* sp (Figure 3), and *Apatococcus* sp (also a green algae) was present as well. In culture, the genera *Leptolyngbya* (cyanobacteria) and *Stichococcus* (green algae) were also present. Probably the proportion of these two algae in the fountain was very small, and that is why they are only observed in culture, where they have better conditions to grow.

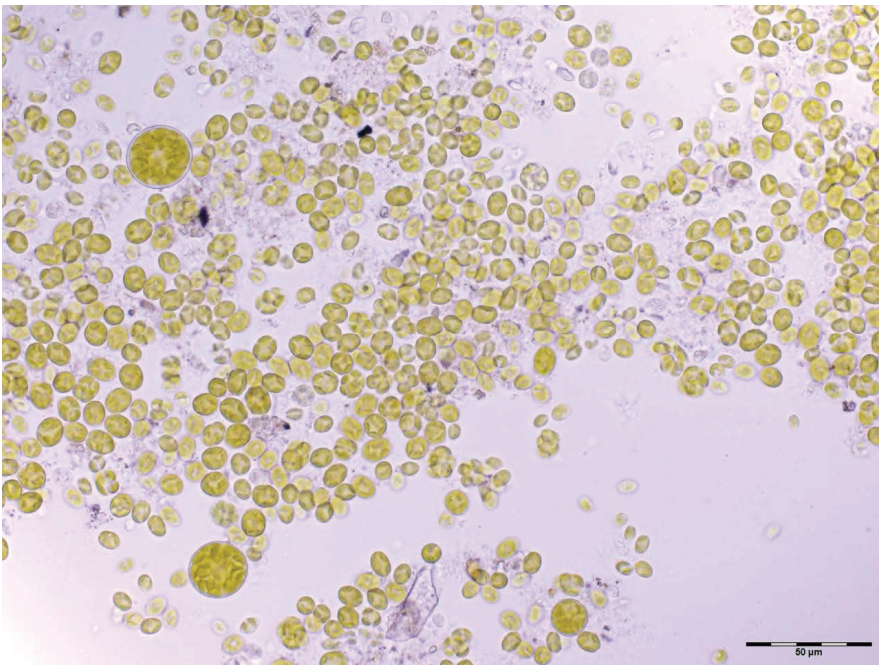

Figure 3. Oocystis sp present at the fountain of Hirshhorn Museum (II). Photograph taken with 400 magnification

In the Large Acanthus Fountain (III), located next to the Arts and Industries Building, the predominant algae are the green algae *Scenedesmus* sp and the filamentous cyanobacteria *Leptolyngbya* sp. The filamentous cyanobacteria *Calothirx* sp is also present, although it is less abundant. In culture, the genus of green algae *Chlorococcum* is frequent, and occasionally *Chroococcidiopsis* sp (coccoid cyanobacteria) and *Calothrix* sp also appear. The latter is less frequent in culture as well, indicating that its proportion in the fountain is smaller.

In the Keith Fountain (IV), located between the Arts and Industries Building and the Smithsonian Castle, the main algae are the filamentous cyanobacteria of the genus *Calothrix* (Fig. 4). The filamentous cyanobacteria *Leptolyngbya* sp and *Pseudanabaena* sp are also present (although the latter is uncommon, and it appears especially in culture due to its low proportion in the fountain). In some areas we have found the coccoid cyanobacteria *Chroococcidiopsis* sp, but it is not very abundant. With respect to the green algae, the main genus is *Scenedesmus*, and there is also presence, although in a smaller proportion, of *Chlamydomonas* sp and *Chlorococcum* sp.

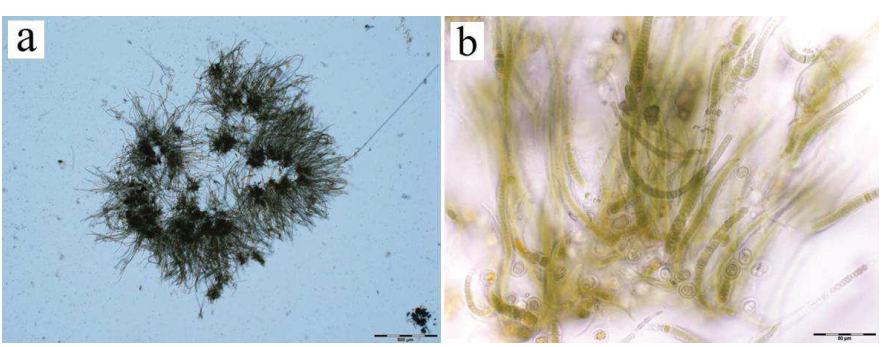

Figure 4. Calothrix sp present at Keith Fountain (IV). a) 100 magnification b) 400 magnification

In the fountain from the National Museum of American History (V) the main type of algae are coccoid green algae. The most frequent is a nonmotile species without pyrenoid, which probably belongs to the genus *Apatococcus* (which we called "*Apatococcus* sp1"). In the samples we also observed some larger cells without pyrenoid of an undetermined species. In culture, in addition to the small algae without pyrenoid, there is growth of *Stichococcus* sp and *Scenedesmus* sp.

There are several species present in the fountain from the National Museum of the American Indian (VI). The most abundant microalgae are coccoid green algae from the genera *Chlorosarcinopsis* and *Scenedesmus*. The genus *Apatococcus* is also present. In some areas of the fountain we found filamentous green algae such as *Ulothrix* sp and *Stichococcus* sp. Regarding cyanobacteria, *Leptolyngbya* sp (filamentous cyanobacteria) and *Myxosarcina* sp (coccoid cyanobacteria) appear, although they are not very frequent, especially *Myxosarcina* sp. The genera of diatoms *Nitzschia* and *Navicula* are also present. In culture, no additional types of algae are present.

In the outside fountain from the National Gallery of Art (VII), which flows into the cafeteria, we found green algae such as *Scenedesmus* sp and other species of round green algae without pyrenoid. *Calothrix* sp also appears, although its proportion is much smaller. It is present mainly in culture, along with *Oocystis* sp.

In the fountain located in front of the southwest façade of the West Building of the National Gallery (VIII), the main type of algae are coccoid green algae. The algae belonging to the genus *Chlorococcum* are the most abundant. *Scenedesmus* sp and *Selenastrum* sp are also present in culture.

Finally, in Girl Water Lilies Fountain (IX, also in the National gallery), we found a green algae possibly belonging to the genus *Apatococcus* (which we called "*Apatococcus* sp2"), and the filamentous cyanobacteria *Leptolyngbya* sp (Figure 5). These same algae grew in culture.

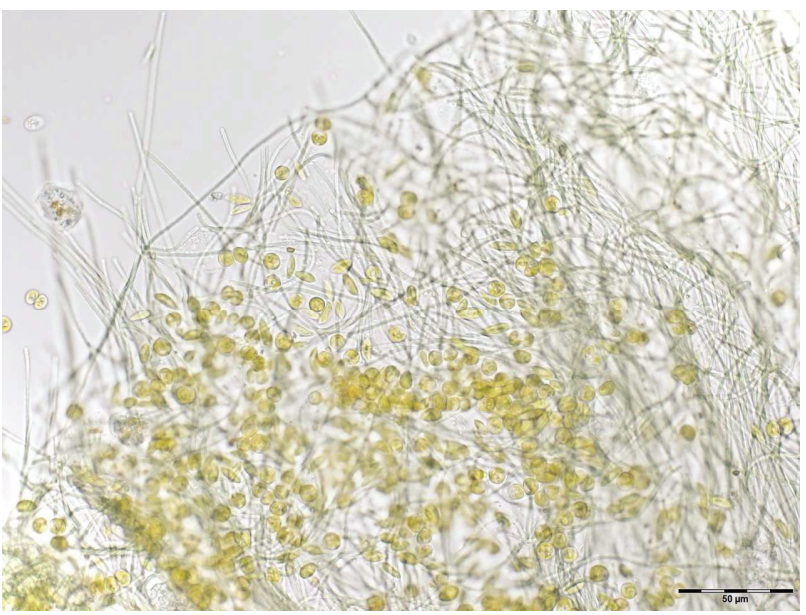

Figure 5. Apatococcus sp2 and Leptolyngbya sp present at Water Lilies Fountain (IX). Photograph taken with 400 magnification.

3.2 *Chromatic diagnosis*

For the chromatic diagnosis we focused on specific areas on each fountain. The films and mats formed by microalgal communities upon the fountains present different color tonalities

depending on the main algae that form those communities. Table 1 shows the relation between color, type of community and main algae present for each studied fountain. Figure 6 shows detail of different chromatic alterations formed by algal communities in different fountains.

Table1. Main color tonalities of the communities found on each fountain and main type of algae that form them.

Fountain	Substratum	Type of community	Colors		Predominant genera
			Faber-Castell	Munsell	
I	Grey granite	Film	188A 167B	2.5YR 8/4 7.5GY 5/8	*Chlorosarcinopsis*
II	Silicone sealant on bronze	Film	167C	7.5GY 4/6	*Oocystis*
III	Iron	Mat	188C 158A 167A	2.5YR 4/4 7.5BG 8/4 7.5GY 7/6	*Calothrix* *Leptolyngbya* *Scenedesmus*
IV	Iron	Mat	189B 167A	10R 8/4 7.5GY 7/6	*Calothrix* *Scenedesmus*
V	Pink granite	Film	167B	7.5GY 5/8	*Apatococcus* sp1
VI	Mineral mortar between limestone	Mat	167B 167A	5G 4/4 7.5GY 7/6	*Chlorosarcinopsis* *Scenedesmus*
VII	Mineral mortar between grey granite	Film	165A 167A	5G 7/4 7.5GY 7/6	*Calothrix* *Scenedesmus*
VIII	Limestone	Film	159B	7.5G 5/6	*Chlorococcum*
IX	Pink marble	Film	165C	5G 4/4	*Leptolyngbya* *Apatococcus* sp2

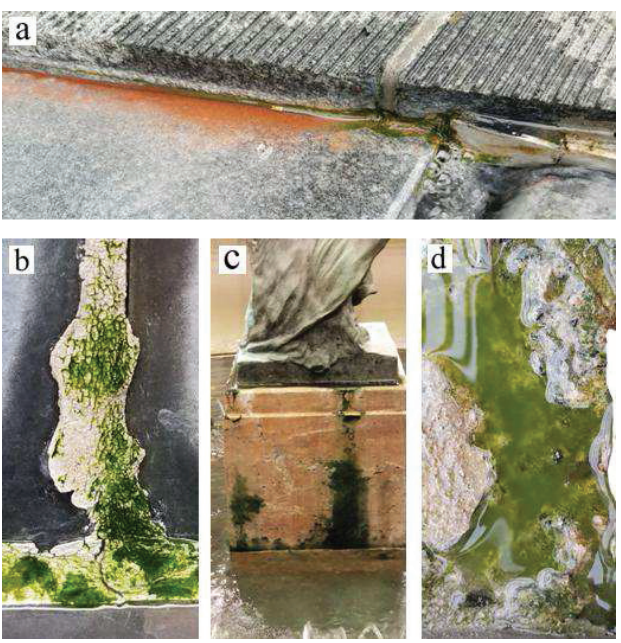

Figure 6. Chromatic alterations caused by microalgae communities. a) Fountain of the National Museum of African American History and Culture (I) b) Fountain of the Hirshhorn Museum (II) c) Water Lilies Fountain (IX) d) Fountain of the National Museum of American History (V)

4 DISCUSSION

As it happened in the work carried out for the doctoral thesis about diagnosis and treatment of algal deterioration in the Alhambra (Bolívar Galiano, 1994), the color of the alterations produced by microalgae serve as an indicator of the type of species that are growing. If we compare our results with the coloring measured with the Faber-Castell color range used in the thesis, we can confirm the correspondence between the blue-green tonalities and the presence of cyanobacteria, and between the yellow-green tonalities and the green algae genera. Comparing samples from the Alhambra and the National Mall of the same period of the year we observe some coincidences, although the methods employed are rather different. The main tonality found in the Alhambra on this period of time (Faber-Castell 167) was also the most frequent on the fountains of the National Mall for this same period.

5 CONCLUSION

The fountains from the National Mall we have studied are made of different materials. The natural color of said materials is affected by microalgal proliferation, that causes changes in coloring due to the algal pigments. These pigments produce around ten different color tonalities with different textures depending on the type of community they appear in. And these communities are formed by different species grouped in more than ten genera. After comparing the different fountains with one another and with the ones studied in the works carried out in the Alhambra, we can conclude that there are many factors that determine the nature of the chromatic alterations, but we confirm that cyanobacteria are invariably responsible for the blue-green coloring and, sometimes, for the cinnamon and sanguine colorings due to the presence of iron oxides. On the other hand, green algae produce yellowish green films and sometimes vermillion-orange coloring as well, when its cystic phase is predominant.

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