

Editorial

Editorial for the Special Issue “Microbial Communities in Cultural Heritage and Their Control”

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Abstract: This editorial focuses on the studies published within the present Special Issue presenting advances in the field of biodeterioration of cultural heritage caused by microbial communities with a particular focus on new methods for their elimination and control.

Keywords: cultural heritage; biodeterioration; microorganisms; biofilms; control

1. Introduction

Cultural heritage plays a key role in understanding the history of humankind; therefore, adopting appropriate strategies for its conservation is essential. Microorganisms, such as bacteria, fungi and microalgae, usually organized on the surface in microbial communities as “biofilms”, can cause serious problems in the conservation of cultural heritage, making the adoption of prevention and conservation strategies a critical issue. The colonization process and the subsequent biodeterioration phenomena strictly depend on the characteristics of the microorganisms, the type of material and the environmental conditions. So, to develop new strategies to eliminate and/or mitigate the presence of biodeteriogens on monuments, it is often necessary to perform interdisciplinary studies aiming to know the state of conservation of the artifact and implement targeted maintenance strategies.

Controlling microorganisms in cultural heritage is a major challenge for microbiologists. The search for appropriate methods to stop progressive microbial attacks without provoking secondary, and perhaps more dangerous, biological succession and biodeterioration is a must.

The aim of this Special Issue was to bring together recent studies presenting cutting edge advances in the field of biodeterioration of cultural heritage caused by microbial communities and their control.

2. Summary of the Special Issue Contents

The Special Issue can be subdivided into three groups according to the topics covered by the articles. Four articles focused on study cases aiming to identify the microorganisms involved in the biodeterioration processes. Seven articles focused on “Green methods” of treatments, of which three investigated the biocidal activity of natural products derived from plants, one each on the biocidal activity of varnishes combined with chemical products, the application of a biocleaning procedure on granite, the potentiality of natural biological control of phototrophic biofilm in cave, and a review on the most innovative antimicrobials among which nano- and bio-technologies play a main role. Finally, two papers focused on the methods for studying biodeterioration.



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2.1. Study Cases

A proper approach that aims to eliminate or mitigate the biodeteriogenic effect that microorganisms have on an artifact should take into account the chemical and physical characteristics of the material, the environmental condition, the description of the alterations and the identification of the main biodeteriogenic microorganisms involved. To identify the complex microbiota composed of dangerous deteriorative microorganisms, it is necessary to apply a multiphasic approach that includes different techniques such as microscopy, cultural dependence and cultural independent analyses as Kizová et al. [1] performed in their contribution on funeral texting items from the 17th century. In particular, cultural methods and the high-throughput sequencing method followed by biodegradative tests and biocide susceptibility of the isolates are useful for a targeted intervention [2].

Another important issue is the creation of a database with the main biodeteriogens and their maintenance in a culture collection. This should be useful not only to obtain a deepened knowledge of the ecophysiological and molecular characteristics of the microorganisms involved in the biodeterioration phenomena, but also to plan trials in situ and in laboratory conditions to develop new strategies for their control. In this regard, Bolívar-Galiano et al. [3] isolated 10 genera of green algae and 13 genera of cyanobacteria from the fountains of Alhambra and Generalife in Spain, thereby constituting the foundation for the creation of a reference collection of living algae.

In the perspective to carry out an intervention of restoration and conservation of monuments or artifact with evident alterations due to the growth of microorganisms, it is always advisable to carry out microbiological analyses before and after treatments and plan subsequent monitoring over time. Caneva et al. [4] in their contribution compared the data coming from the microbiological analyses of Etruscan tombs in Italy and ancient tombs in the Republic of Korea, as well as the conservative treatments carried out at these sites, with a special focus on preventive intervention. Although the hypogean environments are characterized by constant microclimatic conditions with relatively high humidity and constant temperature, the collected data confirmed the complexity of the microbial communities in hypogea as the result of variable environmental values and edaphic conditions. Events that have occurred over time regarding the tombs such as opening, flooding, upper vegetation, visitors, treatment, etc., also played an important role in the biodeterioration processes. In general, they observed the prevalence of autotrophic microorganisms, only if the lighting was sufficient, whereas fungi and bacteria were widespread.

2.2. Green Conservation of Cultural Heritage

In the field of cultural heritage, a very important task is the use of methods of control and treatments that are efficient but not harmful for the material, operator and environment. For this reason, in the last decade scientists have been looking for “eco-friendly” control methods as an alternative to traditional ones such as: aromatic compounds for wood treatments [5]; oregano and clove essential oil as a cleaning method for canvas painting [6]; plant derivatives such as a liquorice leaf extract and lavender essential oil as biocides against phototrophic biofilm growing on stones [7]; water-based gel delivery systems and heating systems for high dimension granite pavement bio-desalination [8], are some examples reported in this Special Issue that seem to be promising for possible future applications.

In other cases, the association of a traditional chemical product such as benzalkonium chloride, o-phenylphenol, and tributyltin naphthenate with natural varnishes should be useful to protect paintings and polychrome sculptures from environmental fungi and bacteria without altering the original materials or the visual appearance of the artworks [9].

Another research field concerns the use of new synthetic molecules to counteract the growth of microorganisms and biofilm formation on stone monuments, such as Ionic Liquids technologies, which can contribute to the production of new formulations of antifouling and antimicrobial surface coatings. These technologies must be defined as eco-friendly [10].

In addition, to biologically derived biocides and chemical methods, natural biological control has been proposed by Jurado et al. [11]. The study of phototrophic biofilms on speleothems revealed the presence of different predators within the complex microbial communities that act naturally controlling the development of photosynthetic-based biofilms in caves.

2.3. Method of Studying

The different kinds of analyses of cultural heritage usually are not standardized methods; however, sampling, microscopy, cultural and molecular analysis procedures are consolidated enough over time to be now used as “Standard” methods by most scientists. Regardless, there are guidelines known as UNINormal techniques, the catalogue for which is accessible on the website [12]. UNINormal collects also over ten years of activities of “The Italian Normal Committee” on cultural heritage and contains information about the descriptions of alterations, methods of cultural analyses and biocide test procedures.

New methods of analyses such as high-throughput next generation sequencing (NGS) have opened new frontiers for the study of the state of conservation and treatments of monuments and cultural heritage items, bringing up new issues regarding their use and standardization. In this Special Issue, Dziurinsky et al. [13] used metabarcoding analyses to select the best culture media combinations to assess the bacterial contamination of air in the Museum of King Jhon III’s Palace in Wilanow (Warsaw, Poland). Ding et al. [14] reviewed the analytical method in use to study the microbiota in cultural properties and historical architecture, from sampling to NGS, which, in combination with cultural and biochemical functional analyses, can provide useful information for further verification of the biochemical and ecophysiological roles of microorganisms in deterioration.

3. Conclusions

Due to the complexity of the topic, the approach to the study of microbial communities responsible for the biodeterioration of cultural heritage cannot be improvised. Descriptions of alterations, methods of study and sampling, implementations of modern and advanced methodologies coming from multidisciplinary approaches are a necessity to study and maintain the cultural heritage in a good state of conservation. Certainly, the eradication and mitigation of bioterrorogenic microorganisms represents the main challenge for microbiologists. Although there is no valid solution for every situation, the acquisition of new eco-sustainable findings and the exchange of experiences in the field can definitely represent a step forward.

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