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Microbial communities on deteriorated artistic tiles from Pena National Palace (Sintra, Portugal)

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ABSTRACT

Pena National Palace (Sintra, Portugal) was built in the 19th century and tiles, typical of Portuguese and Oriental art expression, were widely used as decorative elements throughout the outside walls of the palace. This study focuses on a passageway (Triton tunnel) that is covered with distinct tile panels from the second half of the 19th century, attributed to Wenceslau Cifka. Unfortunately, at present these magnificent tiles are covered by a green and/or black patina caused by microorganisms, whose identification was carried out by culture and molecular methods, light microscopy, confocal laser scanning microscopy, and scanning electron microscopy. Our results showed that the biological patina is composed of microalgae, cyanobacteria, bacteria, and some lichenized fungi. Some of these microorganisms penetrate within fissures and pores, producing tile biodeterioration.

1. Introduction

Pena National Palace, in Sintra, Portugal, was built in the 19th century by Fernando Coburg Gotha (Fernando II), who was influenced by the eclectic and romantic trends of the time. The palace has several outside walls covered with artistic tiles. In this study we focused on a passageway, Triton tunnel, which is covered with distinctive tile panels from the second half of the 19th century, attributed to Wenceslau Cifka.

Tiles are usually made with clay that is mixed with water and subsequently air-dried before firing and are then glazed on one side (Hupa et al., 2005). Glazed ceramic tiles have been used as an ornamental material from antiquity on, and are of great importance in Portuguese, Spanish, and Brazilian cultural heritage. Tiles are frequently treated iconographically with illustrations of great aesthetic value (Oliveira et al., 2001).

Deterioration of ceramic tiles usually occurs when rain or condensed water containing atmospheric acid gases such as SO_2, NO_x, and CO_2 interact with the tile surface and produce acid-soluble constituents. These are transported to sites where recrystallization or precipitation of the new compounds takes place (Larbi, 2004). Dissolution of ceramic matrix constituents tends to increase the capillary porosity of the tiles and consequently renders them more vulnerable to other forms of attack such as frost, wetting, and drying (Yiu et al., 2007). As a result, dissolution and leaching can lead to loss of cohesion and strength or deformation of the material because the volume of the material changes and affects the integrity of the ceramic material. One of the most common problems observed in glazes on ceramic tiles is the penetration of soluble salts, resulting in loss of adherence and consequently the flaking of the glazed surface (Borges et al., 1997).

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In addition, the colonization of ceramic tiles by microorganisms contributes to their deterioration. Nevertheless, there are only a few studies on the biodeterioration of tiles. In fact, some authors have reported the presence of microorganisms and consequent deterioration of unglazed ceramic tiles (Kiurski et al., 2005; Ranogajec et al., 2005, 2008; Radeka et al., 2007a,b; Portillo et al., 2011). Others refer to the colonization of glazed tiles (Oliveira et al., 2001; Watanabe et al., 2006, 2009; Giacomucci et al., 2011; Portillo et al., 2011).

Oliveira et al. (2001) studied the biodeterioration of glazed tiles from buildings in Salvador and Belém, Brazil. Light microscopy revealed dark stains between the glaze and the ceramic body, which were produced by cyanobacteria and diatoms. Watanabe et al. (2006, 2009) reported the process of weathering of glazed Japanese sekishu roof-tiles affected by *Lecidella asema* (a crustose lichen). Light and fluorescence microscopy showed the presence of corrosion pits at the lichen-glaze interface. Pedi et al. (2009) identified several common airborne fungi (*Aspergillus*, *Penicillium*, *Fusarium*, *Geotrichum*, etc.) on deteriorated tiles from Convento de Santo Antônio (Recife, Brazil).

Giacomucci et al. (2011) investigated the biodeterioration of artistic tiles from the façade of the Grande Albergo Ausonia and Hungaria, in Venice. The microbial community was characterized using a PCR–DGGE approach, which revealed that the alterations were produced by bacteria, cyanobacteria, microalgae, and fungi. The phototrophic microorganisms were found to occupy a cryptoendolithic niche.

Identification of microorganisms involved in biodeterioration is one of the most important steps in the process of preservation and conservation of building materials and should be done before any intervention. This identification facilitates an understanding of the role played by microorganisms in the biodeterioration process by correlating the interaction between organism activity and the material. Also, optimum approaches to mitigation can only be achieved with knowledge of the microbial community and their effects. Therefore, the main objective of this work was the identification of the microorganisms responsible for the black and green patinas covering the Triton tunnel tiles, in the Pena National Palace, Lisbon, Portugal, and their role in biodeterioration.

2. Materials and methods

2.1. Site description and sampling

This study focused on a passageway, called the Triton tunnel, in the Pena National Palace, that is covered with distinctive tile panels dating from the second half of the 19th century (Fig. 1) attributed to Wenceslau Cifka. This artist was also known for his work as a photographer, a painter, and also a ceramist; he was known particularly for his Italian Renaissance style faiences (Carneiro, 2009). The passageway goes through the building, connecting the front of a courtyard to a backyard patio. The panels were decorated with plant or heraldic motifs, have a high relief decoration, and were produced using the majolica technique (Fig. 1). The tiles from

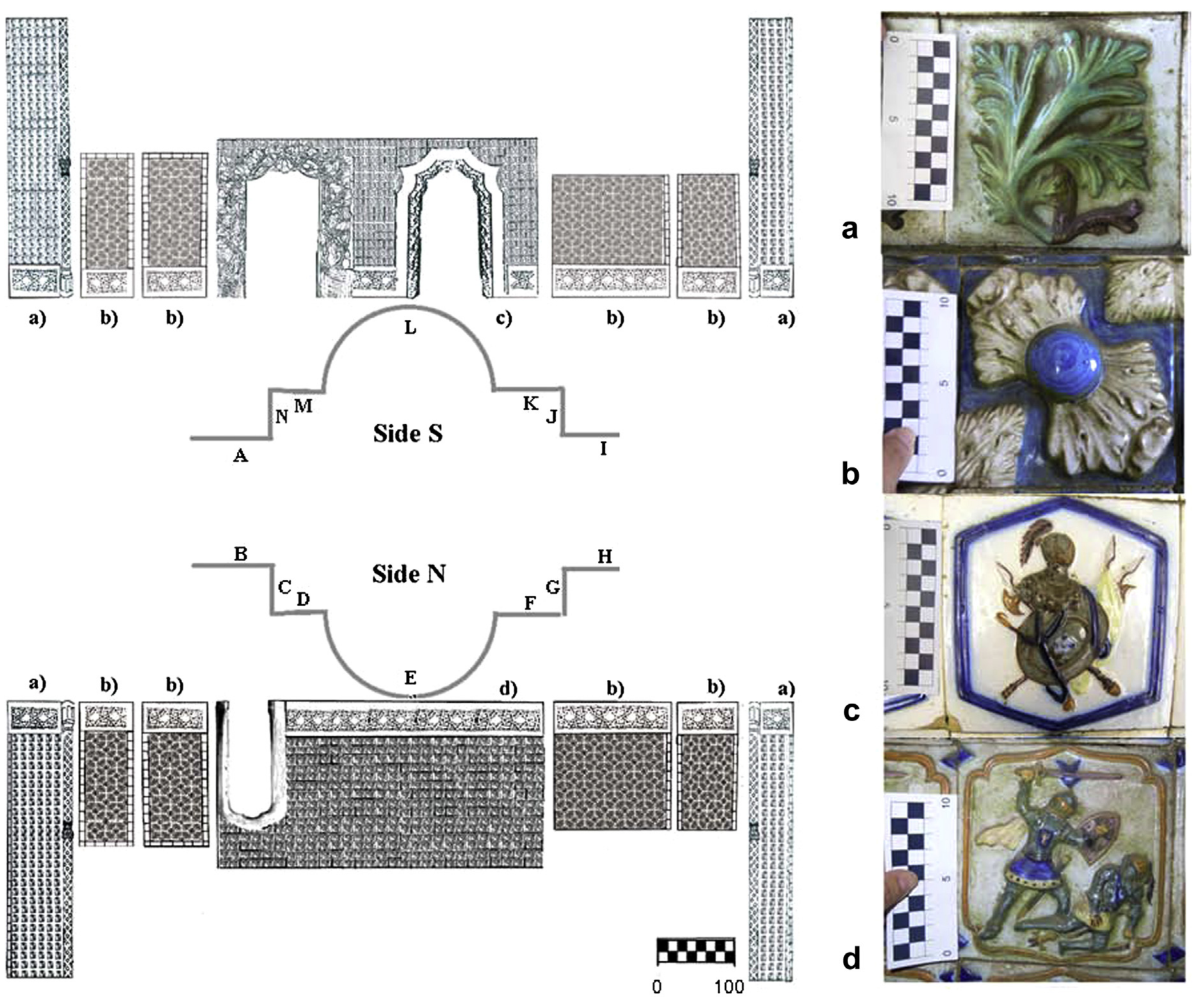

Fig. 1. Scheme of the Triton tunnel passageway with the locations of the panels (A–N) and their tile motifs (a–d). Bar represents cm.