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THE TEMPLE OF APOLLO: AN EXCELLENT HOST FOR BLACK MICROORGANISMS

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ABSTRACT

Turkey is the land of ancient cultures which have lots of ancient monuments, temples and forts. Monuments have continuously been unprotected against physical, chemical and biological deterioration agents. The Temple of Apollo is one of the best preserved temples of Side antique city (Antalya, Turkey), which is important for tourism. However, this temple is a host for biodeterioration agents, which are called black microcolonial fungi causing blackish brown appearance on and within the monument, that, it's considerable for continuity of historical monuments.

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INTRODUCTION

Cultural heritages are important parts of the tourism in many countries. Especially in Turkey, our historical monuments comprise the most important section of the tourism.

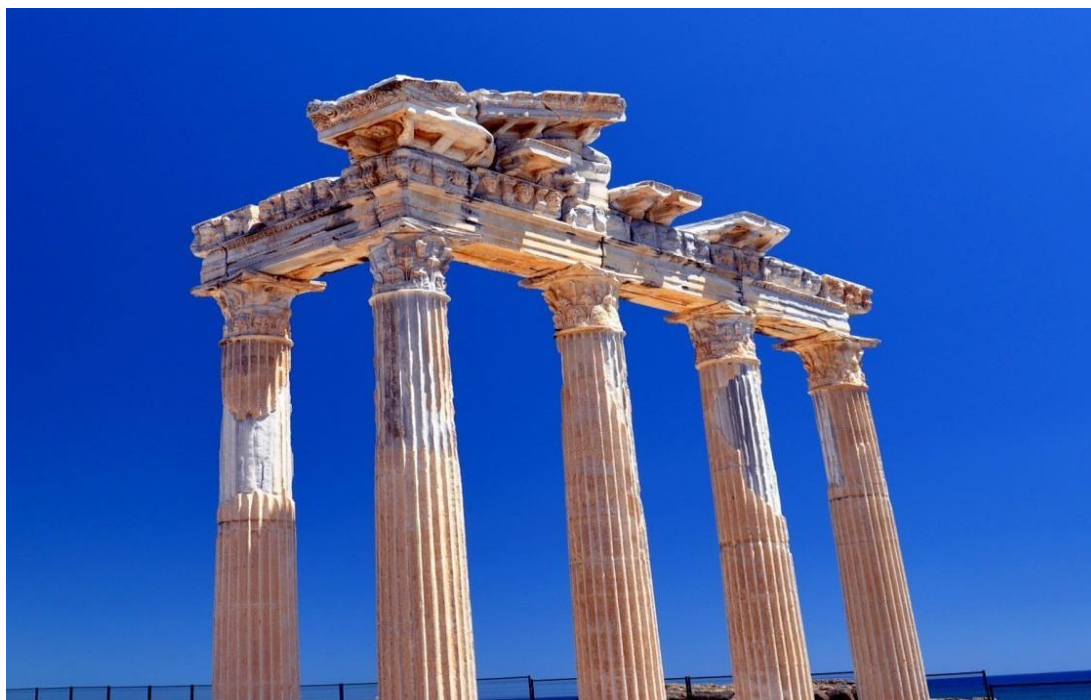
Turkey has a very rich cultural heritage. The variations of its topographical and natural structure presents a variety of sources creating a large collection of sites of natural beauty and antiquities. The quality and amount of this heritage increase the degree of care that should be taken for its preservation and restoration (Sensoy 1990).

Historical monuments are continuously exposed to chemical, physical and biological deterioration agents. Nevertheless, the Temple of Apollo is one of the best preserved temple of Side, situated next to the ancient harbor (Side, Antalya, Turkey) (Figure 1,2), In recent years the importance of biological effects in the deterioration processes of building materials and objects of cultural and historical value has become more and more evident. It has been convincingly shown that biological organisms play an important and substantial role not only in deterioration processes of all organic materials but also of minerals, rocks, ores, natural and man-made glasses, metals and their alloys (Decrouez et al. 1992, de Hoog et al. 2003, Urzi and Krumbein 1994, Staley et al. 1982, Gorbushina et al. 1994, Selbmann et al. 2004, Sterflinger et al. 1998, Sterflinger 2005).

Figure 1. The general view of Side ancientcity (from the top)



Figure 2. The temple of Apollo



The Temple of Apollo; an important temple for tourism, situated in Side antique city, Turkey

There are many tourism activities except mass tourism, such as ecological tourism, health tourism, thermal tourism, religious tourism, sports tourism, cultural tourism etc. Especially, cultural and ecological tourism are very important for Turkey.

Turkey signed the Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) in 1983 and through the work carried out under the responsibility of the General Directorate for Cultural Heritage and Museums, 10 properties were inscribed on the World Heritage List. Among these properties, Historic Areas of Istanbul, City of Safranbolu, Hattusha: the Hittite Capital, Nemrut Dağ, Xanthos - Letoon, Great Mosque and Hospital of Divriği, Archeological Site of Troy and Selimiye Mosque and its Social Complex are listed as cultural, while Hierapolis - Pamukkale and Göreme National Park and the Rock Sites of Cappadocia are listed both as cultural and natural site (www.kultur.gov.tr). Side antique city is one of the best-known cultural sites in Turkey and Side is a site with a long history which has left behind numerous buildings and ruins for us archaeology and history fanatics to explore.

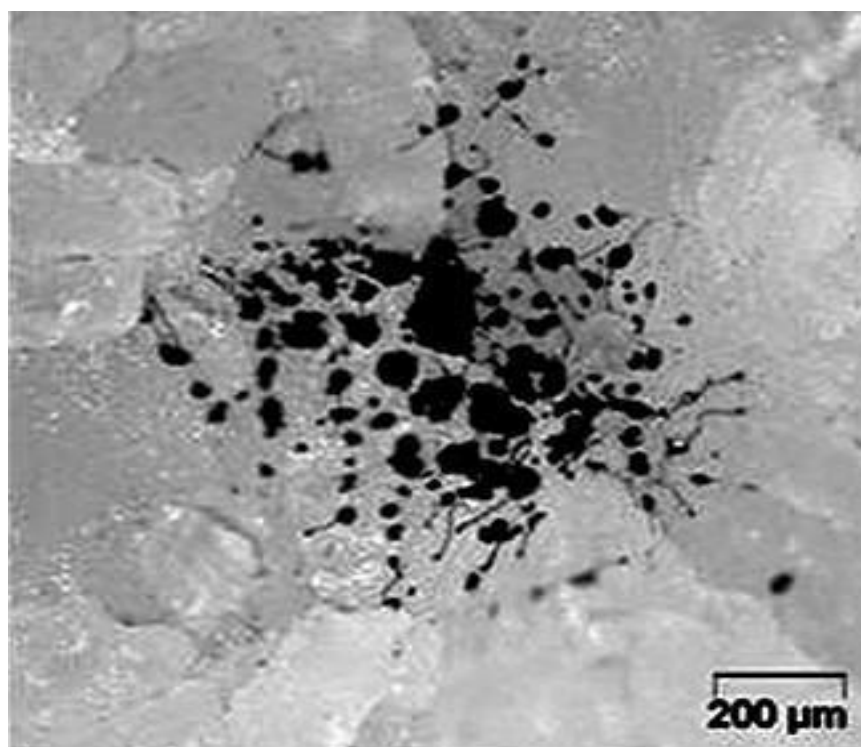
The best preserved temple of the group of three temples on the tip of the Peninsula of Side is the one dedicated to Apollo, the Greek god of beauty, light, the patron of the arts and the guide of the Muses (Miller 2009, Deitsch 2010, Miszczak 2016). Some coins minted in ancient Side show the figure of Apollo standing in front of his temple. From an architectural point of view, this temple was a peripteros i.e. it was surrounded by a colonnade on all four sides of the inner chamber. In the case of the temple of Apollo this colonnade was executed in the Corinthian order. Each longer side of the building was originally adorned with 11 columns and both shorter sides were decorated with 6 columns (Miller 2009, Deitsch 2010, Miszczak 2016).

The Temple of Apollo is a host for biodeterioration agents, which called black microcolonial fungi, sometimes also black fungi, dematiaceous fungi or meristemetic fungi. This slow growing, rock inhabiting fungi have something in common, in that they form cauliflower-like micro colonies on and in rock, they have very thick, multilayered cell wall sand are incrustated with melanins giving them a dark, blackish brown appearance. Generally, meristemetic morphology is interpreted as a response to multiple stress factors (oligotrophic nutrient conditions, elevated temperatures, UV-radiation, osmotic stress) supporting temperature tolerance and decreasing the rate and speed of desiccation by keeping the volume–surface ratio optimal (Wollenzien et al. 1995). The combined influence of these stress factors exerts a high selective pressure on the microbial community and as a consequence black yeast and meristemetic fungi are rarely found in complex microbial populations but solitary

or in spatial association with comparably stress resistant organisms such as lichens and cyanobacteria in very special habitats (Sterflinger, 2005).

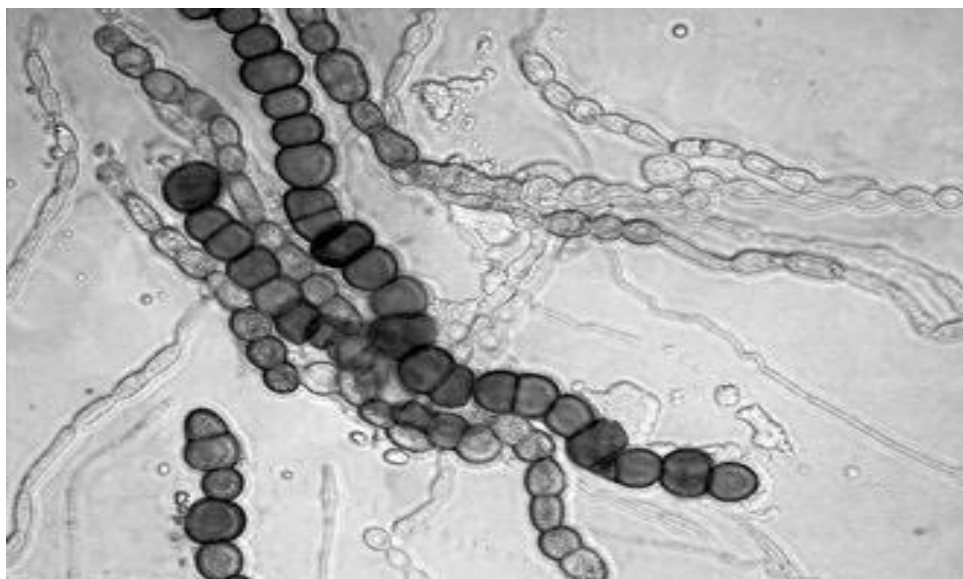
Fungi were first considered to be agents of carbonate deterioration by Krumbein (1969). The mechanical action of fungal growth affects building materials such as brick and concrete (Gravesen et al. 1994) and marble, limestone and sand stone (Sterflinger and Krumbein, 1997) (Figure 3). Their deteriorating effect is due to mechanical and chemical actions as penetration of materials with deep-reaching deteriorating effects, such as swelling and deflation as physical effects, constant micro vibrations through micro motility and acid production (Urzi and Krumbein, 1994). Fungi also play a major role in the color change of rock surfaces. Sterflinger et al. (1998) demonstrated that there is a direct correlation between orange pigmentation (patination) of granite and sand stone and rock inhabiting fungi.

Figure 3. Macrophotograph of micro colonies on marble surface



Many black microcolonial fungi have been isolated from the Stone monuments located in different countries. *Coniosporium*, *Phaeococcomyces*, and *Sarcinomyces* are well-known rock-inhabiting MCF genera (Sterflinger and Prillinger, 2001; Bogomolova and Minter, 2003; Sert et al. 2007). Also *Capnobotryella*, *Exophiala*, *Mycocalicium*, *Trimmatostroma*, *Phaeotheca*, *Phaeosclera* are isolated mostly (Sterflinger and Prillinger, 2001; Bogomolova and Minter, 2003; Sert et al. 2007, Sterflinger 2010, Sterflinger et al. 2014) (Figure 4).

Figure 4. Microphotograph of 1 month-old culture of *Capnobotryella* sp.



As a result, the alteration and deterioration of historical monuments in ancient cities have strong relationship with micro colonies of dematiaceous fungi, which go through the rock and generates colonies within and on it. They caused also color changes (blackish brown appearance, orange patination. etc.), pits and breaks on rock, that, it's considerable for continuity of historical monuments.

Historical monuments comprise the most important section of the tourism of Turkey. Therefore preservation and restoration of historical monuments is very important, especially for cultural and ecological tourism.

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