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Bio-Deterioration and Scientific Preservation of Queen's Mosque

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ABSTRACT

Fungi have an important role in the biodegradation of monuments made of stone. The effect of fungi in the degradation of different types of stone has been widely investigated and demonstrated. Fungi can provide bio-protection for stone surfaces, act as a barrier against weathering, retain moisture, increase waterproofing, reduce thermal stress and corrosion, and absorb pollutants. Nevertheless, the evaluation of biodegradation versus bio-preservation cannot be generalized, as it may vary according to the behavior of different species, as well as that degradation may be influenced by both the lithotype and the environment. In addition to laboratory studies, more field studies of biological communities are needed, in order to analyze their establishment and succession under natural conditions and after conservation treatments. To guarantee the best decision for stone conservation, cleaning operations should not be based on a generalized approach, but on a careful evaluation of different aspects related to biodegradation and bio-preservation. This research paper illustrates the fungal degradation of the stone monument i.e. Queen's mosque and Tomb at Sarangpur, Ahmedabad, Gujarat State and the role of said various fungi in the degradation based on a study jointly conducted by chemists from the Science Branch of Archaeological Survey of India, Vadodara and scientists from the National Research Laboratory for Conservation of Cultural Property, Lucknow.

1. Introduction

Queen's Mosque (Figs. 1 and 2) in Sarangpur was built by Malik Qiwam 'ul-Mulk Sarang. He was a Rajput converted to Islam under the influence of the Sultan and later rose to the status of the Governor of Ahmadabad, in AD 1521, during the reign of Muzaffar Shah II. The Masjid probably built during the second half of the fifteenth century measures 14.56 meters by 11.13 meters on the inside and has five large domes over as many square areas in the sanctuary, entered into through fine arched gateways, the central one being large, higher and with a richly carved arch-rim; The two large-sized minars standing on either side of the centre or now unfortunately extant up to the roof only, resemble closely those of Bibi-Ki-Masjid of Rajpur. The front wall behind the minars is raised on the central portion to about 2.74 meters along a stretch of 12.80 meters but on the interior, there is only a kind of balcony to the gallery resting on pillars of normal height. This is further connected with the gallery under the central dome. The front wall has four perforated windows while on the back wall there are six, with two at the each of side walls [1].

The tomb is juxtaposed in front of the Masjid, as in the case of Rani Sipri's or Sayyid 'Uthman's and stands on a base 22.86 meters square. The outer fringe has 21.74 meters interspaced which had four pairs of coupled pillars on each face with the corner angles totally closed in stone walling while the 20.42 meters inner area was supported by squares of thirty-six, twenty-eight, twenty and twelve pillars raised to 3.96 meters height throughout up to the roof, the innermost square carrying the dome over it. This had also jali-worked screens around it with an entrance on the south side. Twenty pillars which are in the inner square and carries an upper projection has a long gallery there around the central high dome, and has also small corner domes. The two tombs in the rauda had long since been stripped of their marble veneer. While one of them is obviously of Malik Sarang, the other is usually taken to be that of his wife. In its original condition, the rauda would have been very attractive [1].

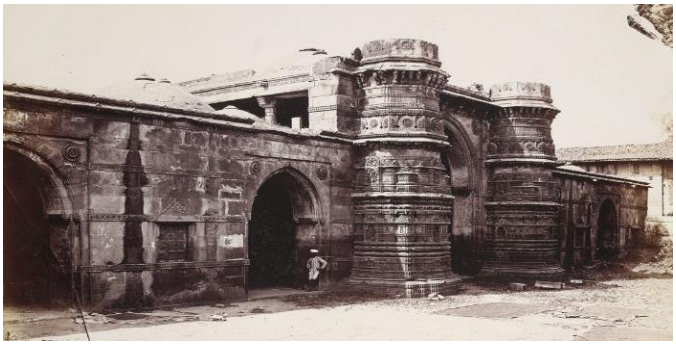

Fig. 1 Front view of Queen's Mosque showing fungal growth on the surface

Fig. 2 Showing different Pillars inside the Mosque

1.1 Bio-Weathering Problem of the Monument

Monument surfaces are constantly affected by physical, chemical and biological factors. Among biological factors, microorganisms are responsible for the destruction of cultural heritage [2-4]. They can damage monuments by forming biofilms on the surface of monuments, chemical reaction with the substrate, and physical penetration into the substrate as well as pigment production. Many studies have dealt with establishing the

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role of biological agents in monument degradation [5,6]. Currently, there is growing concern about the degradation of historical buildings and other monuments due to chemical and physical factors and the growth of microorganisms on the surface of monuments plays an important role in this process [7]. The colonization of microorganisms on stones depends on environmental factors such as water availability, pH, climatic exposure, petroleum parameters such as source of nutrients and mineral composition as well as porosity and permeability of the building materials. The stone ecosystem is subject to drastic environmental changes, particularly highly affected by temperature and humidity [8,9]. All fungi require some organic source for their nutrition and growth, which is provided by metabolites of phototrophic organisms or by air-borne deposition. It has been observed that fungi living in the crevices of certain rocks or monuments have very low nutrient requirements which are met by polluted air and raindrops or by animal remains and secretions [10].

1.2 Conservation Issues

The Queen's Mosque is made of sandstone, which is porous in nature. The mosque appears very old due to the formation of secondary pale greenish white lichen deposits on the surface of the mosque built of stone. The beauty of the mosque has been seriously affected due to these fungal deposits. From the scientific point of view, this fungal deposit is very harmful for the health of the stone surface, as these microbes secrete an acid which dissolves the sandstone. Not only this, the excreta of bats or other birds on the stones is also causing damage to the surface of the mosque because the chemicals found in the excreta of bats and other birds react chemically with the components of the stones and erode them. In such a situation, scientific conservation of the mosque is very important. But before starting the conservation process, it is necessary to examine the factors causing the problem.

2. Experimental Methods

2.1 Sampling and Isolation of Fungi

A total of 10 samples were collected from various places of monument and were brought to the laboratory under aseptic conditions. The isolation of micro- organisms was done by culturing the samples and by direct incubation of samples in moist chamber. The purified fungal cultures were identified (Table 1) by using mycological techniques and were compared with the available authentic literature, reviews and mycological manuals [11-14].

Calculations

Various myco-ecological characters have been calculated using the following formulae:

$$\% \text{ of Frequency (F)} = \frac{\text{Number of samples in which specific organism occurred}}{\text{Total number of samples examined}} \times 100$$

$$\% \text{ of Relative Frequency (RF)} = \frac{\text{Frequency of an individual species}}{\text{Frequencies of all species}} \times 100$$

Table 1 Occurrence, percentage frequency and relative frequency of fungal species

Isolated Fungal Organism	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	F%	RF%
Aspergillus niger	+	+	-	+	+	+	+	+	+	+	90	32.1
Aspergillus sydowi	-	+	+	+	+	-	+	+	-	+	70	25.0
Fusarium species	+	-	-	+	-	-	-	+	+	-	40	14.2
Memnoniella levispora	-	+	+	-	-	-	+	-	-	-	30	10.7
Penicillium citrinum	+	+	+	-	-	+	-	+	-	+	60	21.4
Total											290	103.4

2.2 Removal of Dust and Dirt Deposits

Measures are taken by scientists/chemist or other experts to keep the stone at neutral pH and to remove the dust and dirt deposits to preserve and strengthen the stone by gentle brushing. Moss, fungi and lichens are gradually removed by applying 2-3% solution of ammonia with non-ionic detergent in water and scrubbing with a nylon brush. To prevent further growth of micro-flora, 2% aqueous solution of sodium pentachlorophenate is applied on the cleaned, dry surface. The brittleness and pulverization of stones is preserved by application (brushing and impregnation till saturation) of ethyl silicate based coating material, which forms a glass like silica gel binder (SiO_2 aqueous) with release of ethanol (by evaporation) as a byproduct. It is worth noting that in case of damaged and pulverized stones, the consumption of stone strengthening materials is comparatively more, which penetrates through the pores of the stones and strengthens the stones. Coating of stone strengthener is applied on the damaged and flaky stone surface by simple brushing and impregnation up to saturation [13,15]. Finally it is preserved with suitable chemicals. This time special care is taken in the selection of suitable chemicals so that the use of chemicals does not have any adverse effect on the grandeur of the monument. Before and after scientific conservation of the monument showing in Fig. 3.

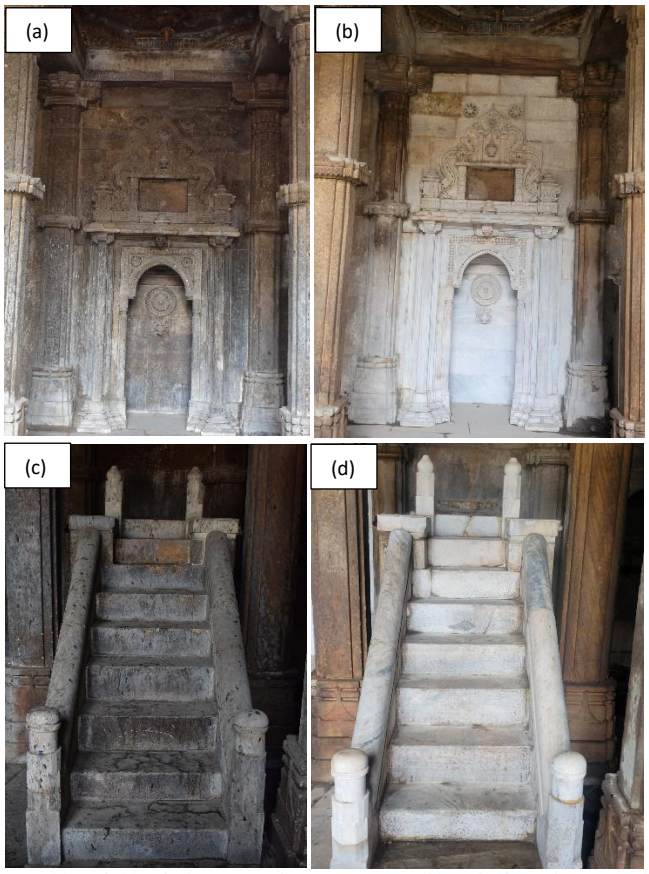
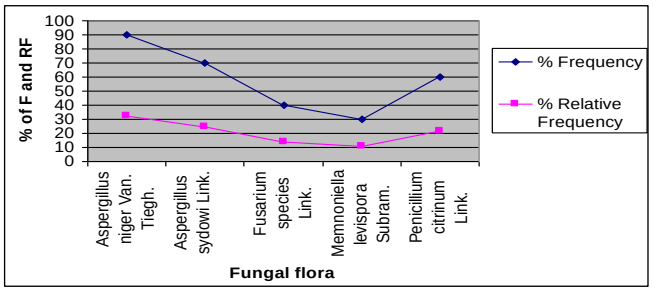


Fig. 3 (a) and (c) - before scientific conservation; (b) and (d) - after scientific conservation



Graph 1 Graph between Fungal flora with their %Frequency (F) and %Relative Frequency (RF)

3. Results and Discussion

The fungal species found in the analysis are typical soil fungi, which is consistent with the results shown [14], which showed a considerable number of fungi of the same genus and species. The identified microscopic fungi can cause mechanical weathering as well as discoloration of the surface of monuments, which can be analyzed through mechanical hyphae penetration and production of various pigments and organic acids. Previous researchers [11,12] have found in their studies that a large number of fungi have a very high potential for biochemical decay. Recent studies have also made it clear that the ability of fungi to form friendly associations with minerals, metals, metalloids and organic compounds through biomechanical and biochemical processes makes them ideally suitable as biological weathering agents of monuments and building materials. Biological and mycological investigations are a very important part of good conservation and cannot be ignored in the modern conservation concept which involves close collaboration between art and science. This analysis is a comparative study of the role of microbial

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colonization on the degradation of historical monuments, heritage and other cultural properties [13,14], which proves beneficial for scientific conservation of cultural heritage. The study found that some fungi were found in all the samples while some were found only in a few samples. A detailed description of which fungi were found in which samples is shown in the Table 1. It was also found in the study that as the probability of occurrence of the fungus (F) increases, its proportional frequency (RF) also increases in the same sequence which is shown through the Graph 1.

4. Conclusion

Cultural heritage, monuments and artifacts are made up of various materials produced by nature and used by man. Objects of cultural heritage, property, monuments, ancient artifacts and other ancient properties are damaged by fungi. The results of this study suggest that these fungi should not be ignored for their potential role in nutrient cycling through bio-degradation of monuments. The expected outcome of this study is that it will provide valuable information about the diversity of fungi involved in the degradation of monuments.

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