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RESEARCH ARTICLE

MYCOLOGICAL STUDY OF FUNGAL SPECIES ON DETERIORATING HISTORICAL MONUMENT WITH REFERENCE TO SHER SHAH TOMB, SASARAM IN BIHAR STATE (INDIA)

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ABSTRACT

Cultural heritage assets are exposed to weather and submitted to the influence of environmental parameters. Physicals, chemicals and biological factors interact with constitutive materials. The air contains a large amount of biological and biotic components such as pollen grains, fungal spores, insects, mites, fibers and dust particles but their number and concentration depend upon the geographical location, types of vegetation and meteorological parameters. Stone objects may support novel communities of microorganisms that are active in the bio-deterioration process. Bio-film on the sandstone monuments contains a complex of consortia of Bryophyta and Fungi. The Bryophyta make up the photosynthetic part of the bio-film while hyphae, filaments and spores take part as fungal components. These structures make a dense layer by intertwining over the surface of sandstone monuments. In the present investigation, 5 (five) samples were collected from different sites of Sher Shah Tomb, Sasaram of Bihar State. The 6 (six) fungal species were isolated which dominate sandstone structures of the monuments. During the investigation, it was observed that *Aspergillus fumigates* was found most dominant followed by *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus terreus*, *Cladosporium cladosporioides* and *Rhizopus spp.* The identified micro fungi cause discoloration as well as mechanical exfoliation of building stone material that was analyzed through mechanical hyphae penetration and production of dark pigments and organic acids. These organic acids are responsible for the bio-deterioration of various cultural objects. Additionally, stone objects may support the communities of microorganisms that are active in the bio-deterioration process. Therefore, the aim of this study is the microbial survey of the tomb of Sher Shah and summarizes data on the fungal impact on bio-deterioration processes.

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INTRODUCTION

There are numerous monuments in Rohtas district of Bihar (India). Sher Shah Suri's tomb is one of them which is located at Sasaram in Rohtas district of Bihar state in India and is assignable to circa 1540-1545. The tomb was built in the memory of Emperor Sher Shah Suri, a Pathan from Bihar who defeated the Mughal Empire and founded the Suri Empire in northern India. The tomb is an example of Indo-Islamic architecture and it was designed by the architect Muhammad Aliwal Khan. The dome of the tomb is made up from the lime plaster stucco technique. The 122 feet height of this tomb was built with red sandstone and stands in the middle of an artificial lake, which is nearly square. The tomb is also known as the second Taj Mahal of India.

The tomb stands at the center of the lake on a square stone plinth with domes kiosks, chhatris at each of its corners. There are stone banks and stepped moorings on all sides of the plinth, which is connected to the mainland through a wide stone bridge. The main tomb is built on an octagonal plan, topped by a dome, 22 meters in span and surrounded ornamental domed kiosks which were once covered in colored glazed tile work. The lake around the tomb is seen as a development in the Afgan phase of Sultan architecture by the Sur Dynasty. The tomb was built during the lifetime of Sher Shah as well as the reign of his son Islam Shah. An inscription dates its completion to 16th August 1545, three months after the death of Sher Shah (Fig. A & B). During recent decades there has been a general concern about the deterioration of historical monuments. Numerous factors affect stone durability. Stone surfaces are continuously exposed to physical, chemical and biological degradation. Physical, chemical, and biological agents act in co-association, ranging from synergistic to antagonistic, leading to the deterioration (Gupta, 2017). The microbial metabolites of bio-films are responsible for the deterioration of the underlying substratum and may lead to physical weakening

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and discoloration of sandstone (Gupta, 2012). The condition of the monuments depends on the use of them, also plays a vital role, which deteriorates the monuments. The development of specific species on a particular stone surface is determined by the nature and properties of the stone. The response of a living organism to a potentially colonizable surface depends on ecological species involved (Kumar, 1999). Microorganisms participate actively in the weathering of minerals (Banfield, 1997). Microbial processes leading to the degradation of mineral may include microbial oxidation and reduction, creation and maintenance of appropriate physicochemical conditions, and production of acidic metabolites (Barker, 1997). These microbial-mediated processes are partially responsible for the chemical and physical weathering of rocks, which lead, eventually, to the formation of soils. Microorganisms may also contribute to the deterioration of stone artifacts such as historical monuments and statues. Most authors have tested acid production by isolated microorganisms in laboratory cultures, in the absence of the stone substrate, extrapolating these results to the field situation as well as climatic conditions. This work aims to study the microfungi community on monuments by using fungal ecological parameters and microscope observations to evaluate the importance of value index and damage caused by fungal species.



Fig. 1. General view of Sher Shah Suri Tomb (A); Close view of Sher Shah Suri main Tomb (B)

MATERIALS AND METHODS

Sampling and Isolation of Fungi: Total 5 Samples were collected from various locations of Shershah Suri Tomb, Sasaram, Bihar, and brought to the laboratory under aseptic conditions. The isolation of microorganisms was done by culturing the samples (Fig. C-D) and by direct incubation of samples in the moist chamber. During the investigation period, PDA media was used for the isolation of microorganisms. A few drops of sample poured in the Petridis and kept this Petridis at $28 \pm 1^\circ\text{C}$ for 07 days for incubation. At the end of incubation period, fungal colonies were identified by using mycological techniques and compared with the available authentic literature, reviews and mycological manuals (Alexopoulos, 1978; Barnett, 1978; Ellis, 1976; Gilman, 1995).

Calculations

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

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

$$\text{Density (D)} = \frac{\text{Total number of colonies of a specific organism}}{\text{Total number of plates examined}}$$

$$\text{Abundance (Ab)} = \frac{\text{Total number of colonies of a specific organism}}{\text{Number of plates in which specific organism occurred}}$$

RESULTS AND DISCUSSION

During screening for the search of mycoflora, total of six species of fungal organisms were isolated from Sher Shah Suri Tomb, Sasaram (Table - 1). In the Sher Shah Suri tomb, *Aspergillus fumigates* show maximum frequency, Density as well as Abundance, followed by *Aspergillus niger*. Some of the fungal species are confined to a particular area i.e. *Aspergillus flavus*, *Aspergillus terreus*, *Rhizopus nodosus* and *Cladosporium Cladosporioides* (Fig.2 A-F). These confinements of fungal species depend on the environmental conditions of the area, which varies from geographical area to area (Salvadori, 2000). In the present study, *Aspergillus* species are the most common species found in the sites.

The variation in the composition of a fungal organism depends upon the biochemical nature of the host, degree of competition between the fungal organisms and the prevailing environmental conditions. The frequency and relative frequency are directly or indirectly correlated with meteorological data and climatic conditions (Chandel, 1990). In each fungal community, all the species are not equally important. There are relatively only a few of these, which determine the nature of the community (Simpson, 1949). These few species exert a major controlling influence on the community and play an important role in the deterioration of various substrates. It has also been shown in the laboratory that fungal species such as *Aspergillus fumigates* were able to solubilize powdered stone and chelate various minerals in a rich glucose medium because they produce organic acids such as gluconic, citric, and oxalic acids (Lapidi, 1973). The toxic metabolites produced by various species of fungal organisms function as chelating agents that can leach metallic cations, such as Iron, Magnesium, etc. from the stone surface

Table 1. Observation

S.No.	Isolated fungi	Samples					F %	D	Ab
		S1	S2	S3	S4	S5			
1.	<i>Aspergillus fumigates</i>	1	2	1	2	3	100	1.80	1.80
2.	<i>Aspergillus niger</i>	1	3	-	1	1	80	1.20	1.5
3.	<i>Aspergillus flavus</i>	2	-	1	1	-	60	0.80	1.33
4.	<i>Aspergillus terreus</i>	1	1	1	-	-	60	0.60	1.00
5.	<i>Rhizopus nodosus</i>	1	1	-	-	-	40	0.40	1.00
6.	<i>Cladosporium Cladosporioides</i>	-	-	1	-	-	20	0.20	1.00

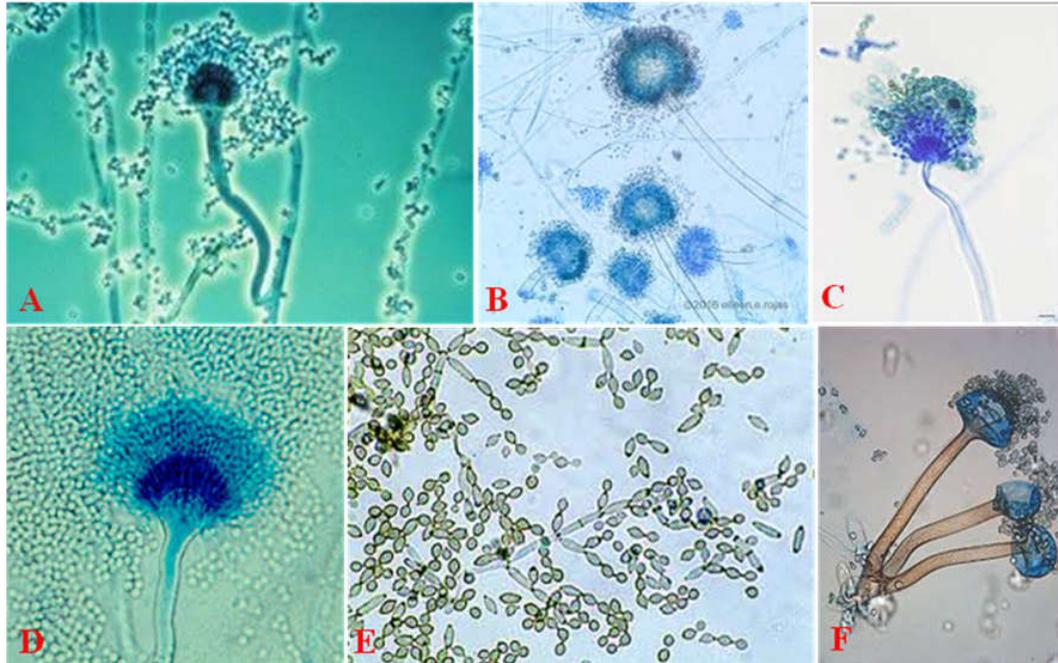


Fig. 2. A- *Aspergillus fumigates*, B- *Aspergillus niger*, C- *Aspergillus flavus*, D- *Aspergillus terreus*, E-*Rhizopus nodosus* and F- *Cladosporium cladosporioides*

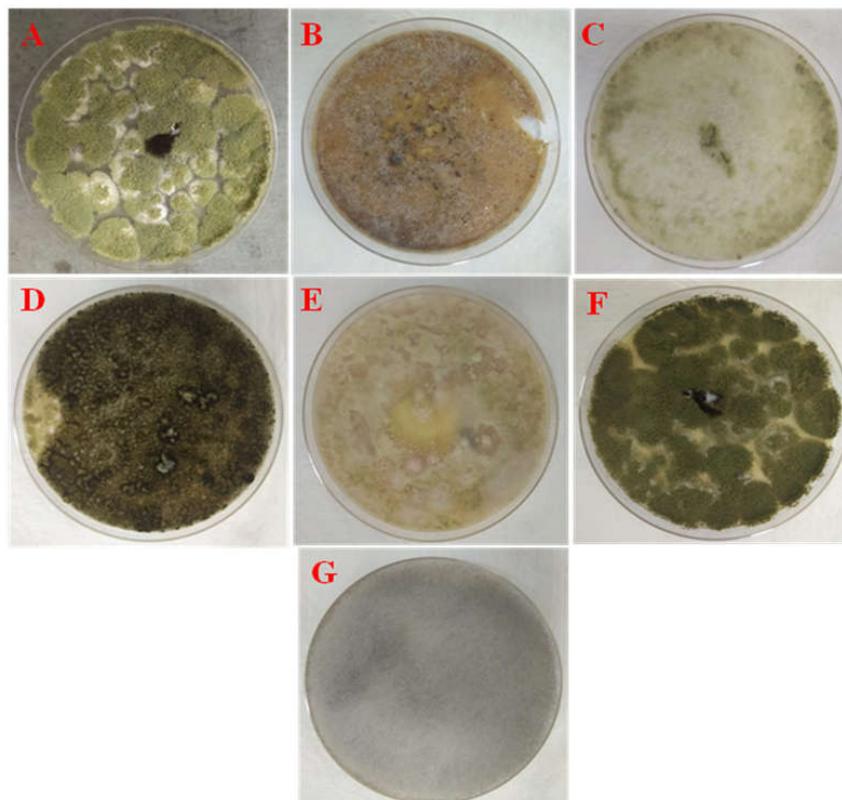
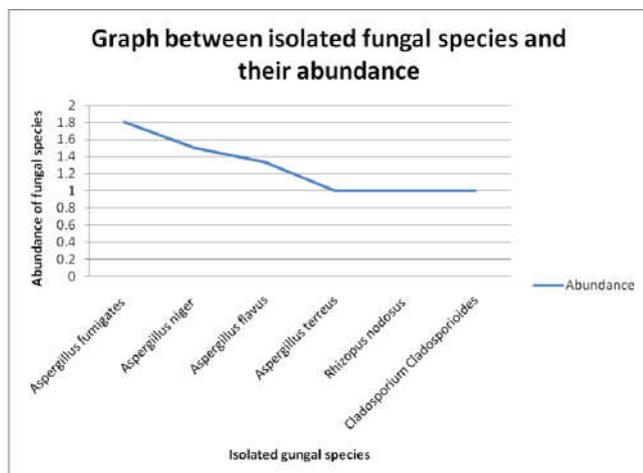
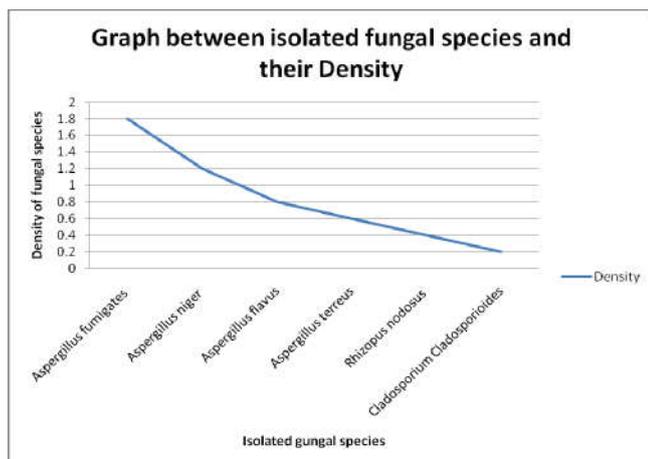
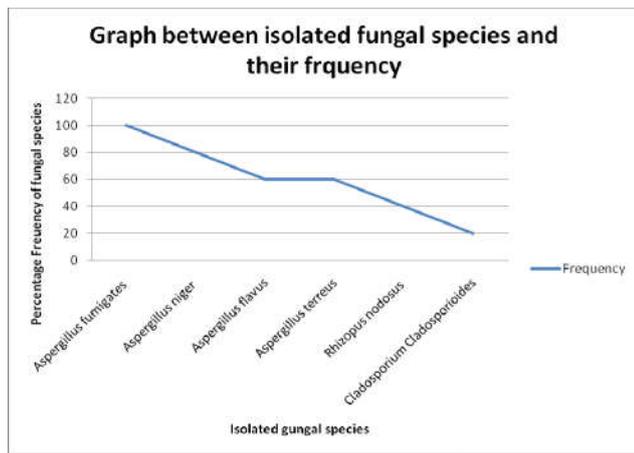


Fig. 3. A- Composite colony of fungal species, B- *Aspergillus niger*, C- *Aspergillus flavus*, D- *Aspergillus terreus*, E-*Rhizopus nodosus* F- *Cladosporium cladosporioides* and G- *Aspergillus fumigates*



(Boyle, 1973). Laboratory experiments have demonstrated that basic rocks are more susceptible to fungal attack than acidic rocks. In the present study, *Aspergillus* species are the most common species found in the sites.

Conclusion

During screening for the search of mycoflora, a total of six species of fungal organisms were isolated from the site. In our study, we found that the *Aspergillus fumigatus* shows maximum frequency, Density as well as Abundance, followed by *Aspergillus niger*. Some of the fungal species are confined to a particular area i.e. *Aspergillus flavus*, *fumigates*, *Aspergillus terreus*, *Rhizopus nodosus* and *Cladosporium Cladosporioides*. These confinements of fungal species depend on the environmental conditions of the area, which varies from geographical area to area (Salvadori, 2000).

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