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RESEARCH ARTICLE

FUNGAL INVOLVEMENT IN BIO WEATHERING OF HISTORICAL MONUMENT WITH REFERENCE TO BATESHWAR HINDU TEMPLES, MORENA TOWN OF MADHYA PRADESH, INDIA

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ABSTRACT

Fungi are complex communities of microorganisms that damage historic monuments. The present study was made to examine the diversity of fungi associated with deteriorated monuments sites. In the present investigation, 10 samples were collected from various portions of deteriorating sites of Bateshwar Hindu temples at Morena Town of Madhya Pradesh state of India. Five fungal species isolated from deteriorated monument sites are reported in this paper. The most frequent isolated fungal species from the historic monument sites are *Aspergillus niger.* Present biological and mycological investigations focused on bio-deterioration of said monument by various fungal species.

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INTRODUCTION

History of Bateshwar Hindu temples: The Bateshwar Hindu temples are a group of nearly 200 sandstone Hindu temples and their ruins in north Madhya Pradesh in post-Gupta, early Gurjara-Pratihara style of North Indian temple architecture. It is about 35 km north of Gwalior and about 30 km east of Morena town. The temples are mostly small and spread over about 25 acres site. They are dedicated to Shiva, Vishnu and Shakti - representing the three major traditions within Hinduism. The site is within the Chambal River valley ravines, on the north-western slope of a hill near Padavali known for its major medieval era Vishnu temple. The Bateshwar temples were built between the 8th and the 10th-century.The site is likely named after the Bhuteshvar Temple, the largest Shiva temple at the site. It is also referred to as Batesvar temples site or Batesara temples site. The Bhutesvara temple had a square sanctum with a 6.75 feet side, with a relatively small 20 square feet *mahamandapa*. The sanctum doorway was flanked by river goddesses Ganga and Yamuna. The tower superstructure was a pyramidal square starting off from a 15.33 feet sided square seated on a flat roof and then rhythmically tapering off [1].

Significance: According to Michael Meister, the Bateshwar site illustrates the conception and construction of "Mandapika shrine" concept in central India.

It is reducing the Hindu temple idea to its basics, in a simple concept that is one step further from the single cave cell design. This design has roots in more ancient Hindu temples found in this region such as one that survives at Mahua and has a Sanskrit inscription that calls the design as *sila mandapika* (literally, a "stone pandal or pavilion". This has vedi-platform roots that combines the traditional square plan with various combinations of Hindu temple architecture elements. The temples explore a square sanctum mounted on a basement platform (*jagati*) that is rectangular, states Meister, so as to incorporate a small *praggriva* (porch).The significance of these temples is that they fuse and experiment with a variety of temple building ideas, such as topping the nagara sikharas that may have been dominant by that time possibly in western India, on the simplest of temple grid plans with more ancient roots in central India[2].

Modern History of Bateshwar temple: The site was visited and its ruins reported by Alexander Cunningham in 1882 as a "collection of more than 100 temples large and small to the southeast of Paravali (Padavali)", the latter with a "very fine old temple". Bateshwar was notified by Archaeological Survey of India (ASI) as a protected site in 1920. Limited recovery, standardized temple numbering, ruins isolation with photography and site conservation effort was initiated during the colonial British era.

Fig. 1. Three floor plans at the Bateshwar site

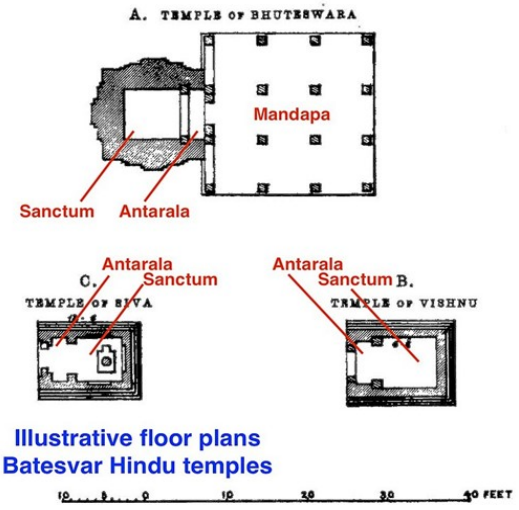


Fig. 2. Ruins of Bateshwar temple

Several scholars studied the site and included them in their reports. For example, the French archeologist Odette Viennot published a paper in 1968 that included a discussion and photographs of the numbered Batesvar temples[1-2].

Fig. 3. Ruins and different styles of Bateswar site

Fig. 4. Micro organism growth on the surface

Fig. 5. Micro organism growth on the surface

Causes of deterioration of monuments: Sandstone surfaces of monument are continuously affected by physical, chemical and biological agents. Among biological agents, microorganisms are responsible for the destruction of cultural property[3-4]. They can cause damage on the stone surface such as formation of bio-films, chemical reactions with the substrate, physical penetration into the substrate as well as pigment production. Numerous studies have dealt with establishing the role of biological agents in the stone deterioration[5-6]. During recent decades there has been a growing concern about deterioration of historic buildings. Along with chemical and physical factors, microbial growth plays an important role in this process[7].

Microbial colonization of stones depends on environmental factors such as water availability, pH, climatic exposure, nutrient sources, and petrologic parameters such as mineral composition, type of cement, as well as the porosity and permeability of rock material. The stone ecosystem is subject to harsh environmental changes, especially due to temperature and moisture, exerting extreme selective pressure on any developing microbial community [8-9]. All fungi need some organic source for their growth, which is provided by metabolites of phototrophic organisms or by air-borne deposition. It has been shown that very low nutrient requirements of some rock inhabiting fungi may be fulfilled by remains of polluted air and rain or animal remains and secretion[10].

Fig. 6. Showing micro-organism growth on the monuments showing micro- organism growth on the monuments

Conservation issue: The Bateshwar temple is built of sand stone, which is porous in nature. The surface deposits seem to be very old due to the formation of secondary dull green pale white lichens, which are present all over the stone surface. Due to these growths of microbes, the aesthetic beauty of the temple is seriously affected. From a scientific point of view these growth of microbes are very harmful for the health of the stone surface, because these micro organisms secrete an acid that dissolves the sand stone[11].

MATERIALS AND METHODS

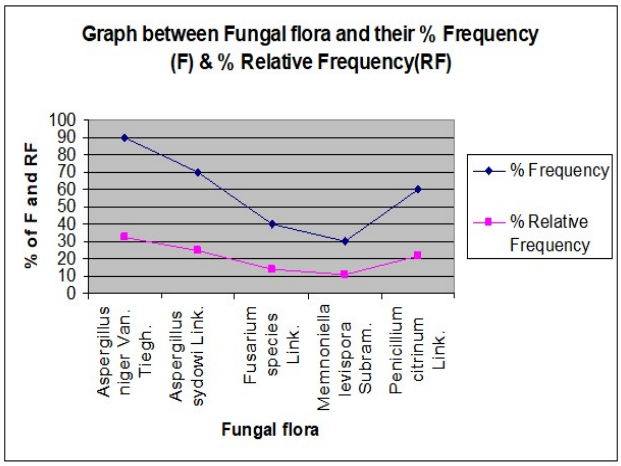
Sampling and Isolation of Fungi: A total of 10 samples were collected from various places of monument and were brought to the laboratory under aseptic conditions. The isolation of micro- organisms was done by culturing the samples and by direct incubation of samples in moist chamber. The purified fungal cultures were identified (table) by using mycological techniques and were compared with the available authentic literature, reviews and mycological manuals[9-10].

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

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

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

Fig. 7. Ruins and different styles of Bateswar site along with



Graph 8. gungalflora and % frequency & %RF

RESULTS AND DISCUSSION

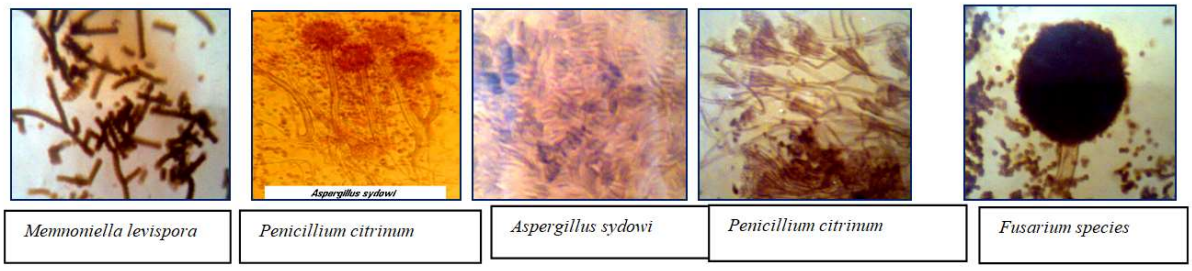
The mentioned fungal species are typically soil fungi, which is in accordance with the results of ref [9] who noted a considerable number of the same genus and species. The identified micro fungi cause discoloration as well as mechanical exfoliation of stone material that was analyzed through mechanical hyphae penetration and production of different pigments and organic acids. Refs[9] reported that a large number of fungi have great biochemical decay potential. Recently, it has been apparent that the ability of fungi to interact with minerals, metals, metalloids and organic compounds through biomechanical and biochemical processes, makes them ideally suited as biological weathering agents of rock and building stone. Biological and mycological investigations are a very important part of good conservation and cannot be ignored in the modern conservation concept, which includes close collaboration between art and science.

Table 9. Observation Table

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 Van. Tiegh.	+	+	-	+	+	+	+	+	+	+	90	31.03
Aspergillus sydowi Link.	-	+	+	+	+	-	+	+	-	+	70	24.13
Fusarium species Link.	+	-	-	+	-	-	-	+	+	-	40	13.79
Memnoniella levispora Subram.	-	+	+	-	-	-	+	-	-	-	30	10.34
Penicillium citrinum Link.	+	+	+	-	-	+	-	+	-	+	60	20.68
Total											290	99.97

CULTURE PLATES (10)

CULTURE PHOTOGRAPHS (11)



This collaboration is the comparative study of the role of microbial colonization on the degradation of historic monuments[10].

CONCLUSION

Cultural heritage is made up of a variety of material produced by nature and used by man. Cultural heritage objects are subjected to damage by fungi. The results of this study suggest that these fungi should not be ignored for their potential role in nutrient cycling by bio-deterioration of monuments. The possible outcome of this study is that valuable information about the diversity of fungi involved in the deterioration on monuments will be obtained.

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