



## DIVERSITY OF MONUMENT DETERIORATION-CAUSING FUNGI AT GWALIOR FORT (M.P.) INDIA

A.K. Pandey<sup>1</sup>, Archana Shrivastav<sup>2</sup>, Preeti Bhatnagar<sup>2</sup>, S. Sarsaiya<sup>1\*</sup>, M.K. Awasthi<sup>1</sup>

<sup>1</sup> Mycological Research Laboratory, Department of Biological Sciences, Rani Durgavati University, Jabalpur- 482001 (M.P.) India

<sup>2</sup> College of Life Sciences, Cancer Hospital & Research Institute, Gwalior (M.P.), 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, 40 stone samples were collected from 15 deteriorating sites of Gwalior Fort. A dilution plate method was used for isolation of fungi. Twenty-three fungal species containing 19 genera isolated from fifteen deteriorated monument sites are reported in this paper. The most frequent isolated fungal species from the historic monument sites are *Alternaria* sp., *A. nidulans*, *A. fumigatus*, *A. flavus*, *A. terreus*, *A. niger*, *Beauveria* sp., *Bipolaris* sp., *Curvularia* sp., *Cochliobolus* sp., *Cladosporium* sp., *Chaetomium* sp., *Cryosporium* sp., *Conidiobolus* sp., *Drechslera* sp., *Exserohilum* sp., *Fusarium* sp., *Penicillium* sp., *Sepedonium* sp., *Scopulariopsis* sp., *Trichothecium* sp., *Torula* sp. and *Ulocladium* sp. The Bhimsen Chatri, Gujri Mahal and Man Mandir sites contained the maximum number of fungal species followed by Barak, Bawari, Bahu Mandir, Bhim Singh Chatri, Rang Mahal, Karan Mahal, Fansighar, Teli Ka Mandir, Jail, Sas Mandir, Unknown site 1, Unknown site 2 and Vikram Mandir. The diversity of these fungi associated with deteriorated monuments sites provides valuable data for future studies.

\* Corresponding author: Surendra Sarsaiya, Regional Office, M.P. Pollution Control Board, Vijay Nagar, Jabalpur (M.P.), India, E-mail: surendra\_sarsaiya@yahoo.co.in

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### 1. INTRODUCTION

Gwalior Fort (Figure 1) is one of the most invisible forts in India. It is built on a hill of sandstone. Its sandstone surfaces are continuously affected by physical, chemical and biological agents. Among biological agents, microorganisms are responsible for the destruction of cultural heritage [1-3]. They can cause damage on the stone surface such as formation of biofilms, 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 [4,5]. 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 [6].

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 [7,8]. 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 [9]. The present study was initiated to isolate diversity of deterioration-causing fungi for further research.

### 2. MATERIALS AND METHODS

#### 2.1. Collection of Samples

Deteriorated stone samples were collected from 15 different localities of Gwalior Fort (M.P.), India namely Barak, Bawari, Bahu Mandir, Bhim Singh Chatri, Gujri Mahal, Man Mandir, Rang Mahal, Karan Mahal, Fansighar, Teli Ka Mandir, Jail, Sas Mandir, Unknown Site 1, Unknown Site 2 and Vikram Mandir (Figure 2). After careful observation, visible alterations and degradation were mapped and after that the samples were taken. All samples were

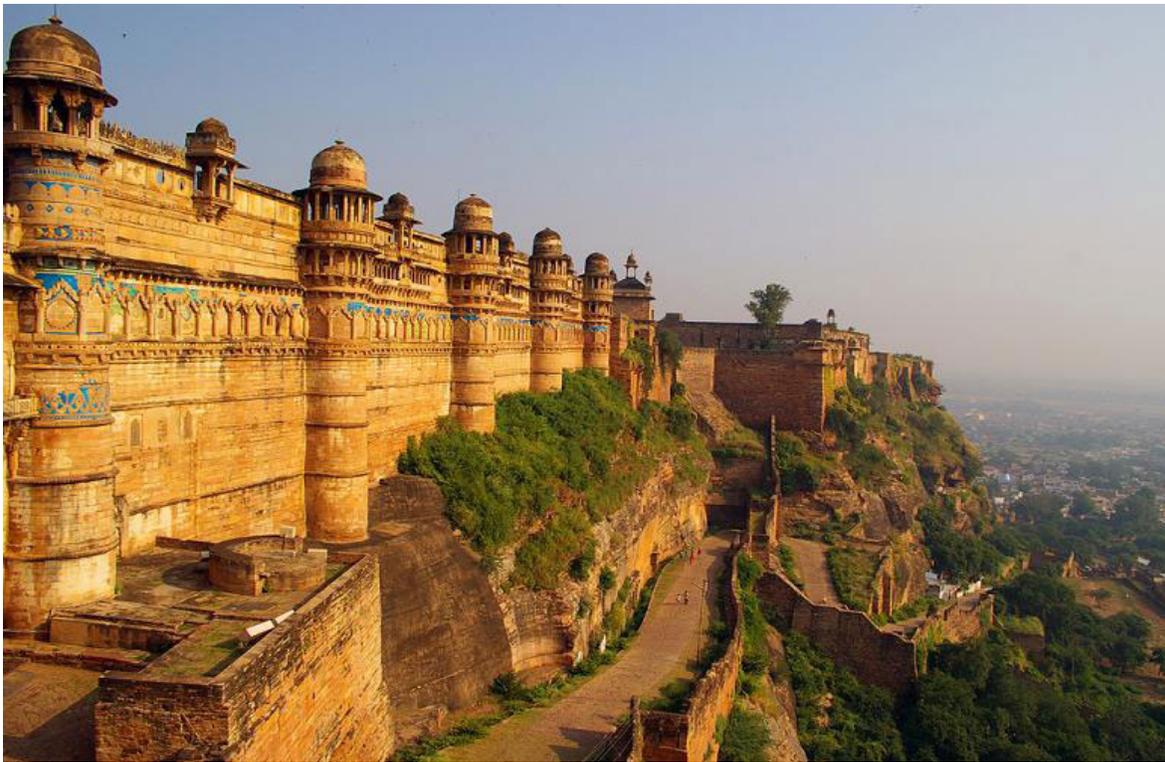
processed within 5 hrs of collection.

## 2.2. Isolation of Fungi

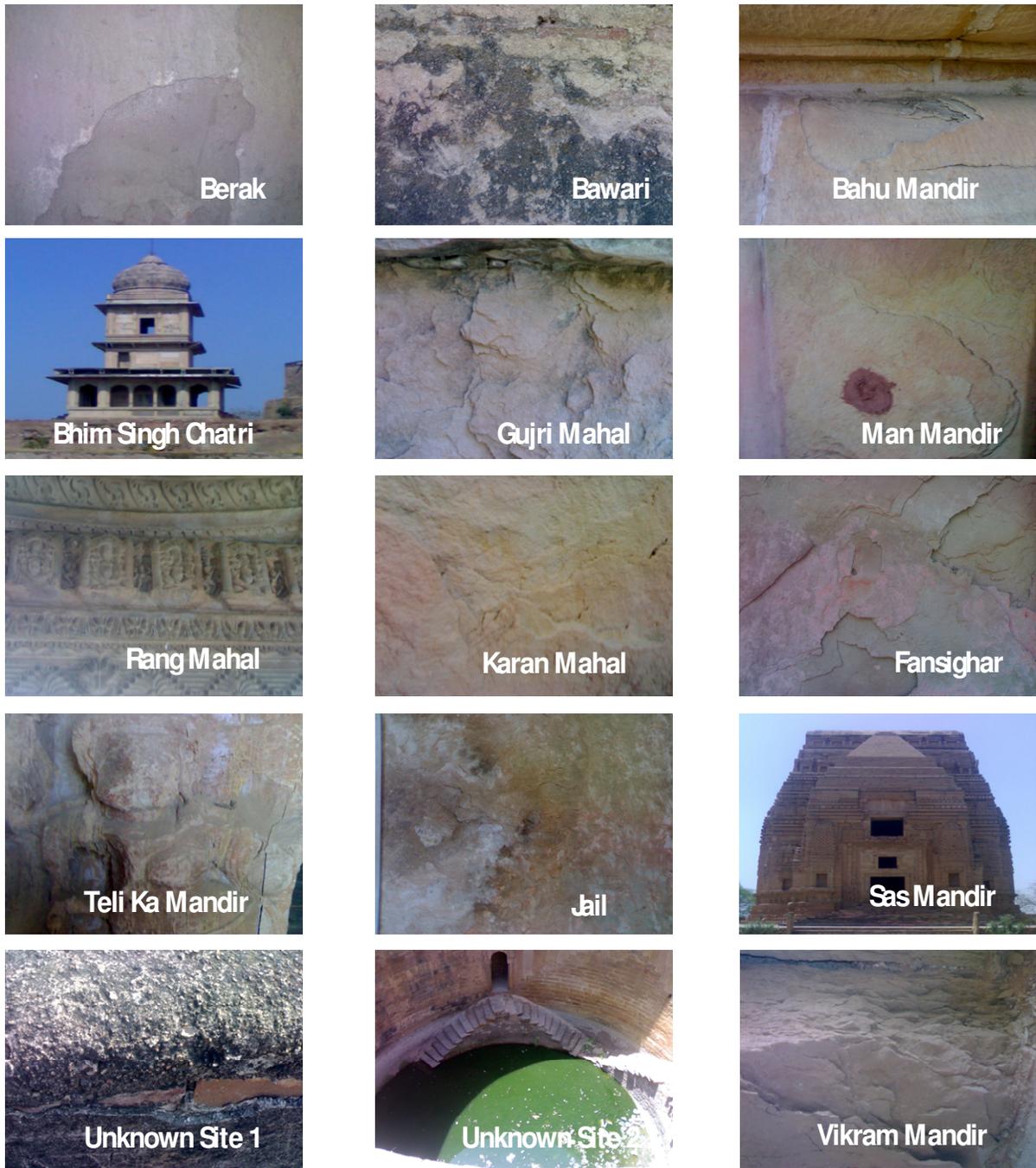
A dilution plate method was used for isolation of fungi, [10]. One gram of fresh ground samples were placed in 10 mL of sterile distilled water and shaken by vortexing the mixture for 30 min at room temperature. Then 100  $\mu$ L portions of the suspensions were inoculated onto plates containing potato dextrose agar containing 20% potato, 2.0% dextrose and 15% Agar (w/v). Chloramphenicol was added to the molten medium after autoclaving. The plates were incubated at  $28 \pm 2^\circ\text{C}$  for 4-8 days and examined regularly. As soon as the colonies appeared, they were transferred to potato dextrose agar slants. The isolated fungi were purified by the single spore method [10]. Isolated fungal strains were identified on the basis of morphological studies [11-14]. The identified strains were maintained on PDA slants at low temperature ( $4 \pm 1^\circ\text{C}$ ).

## 3. RESULTS

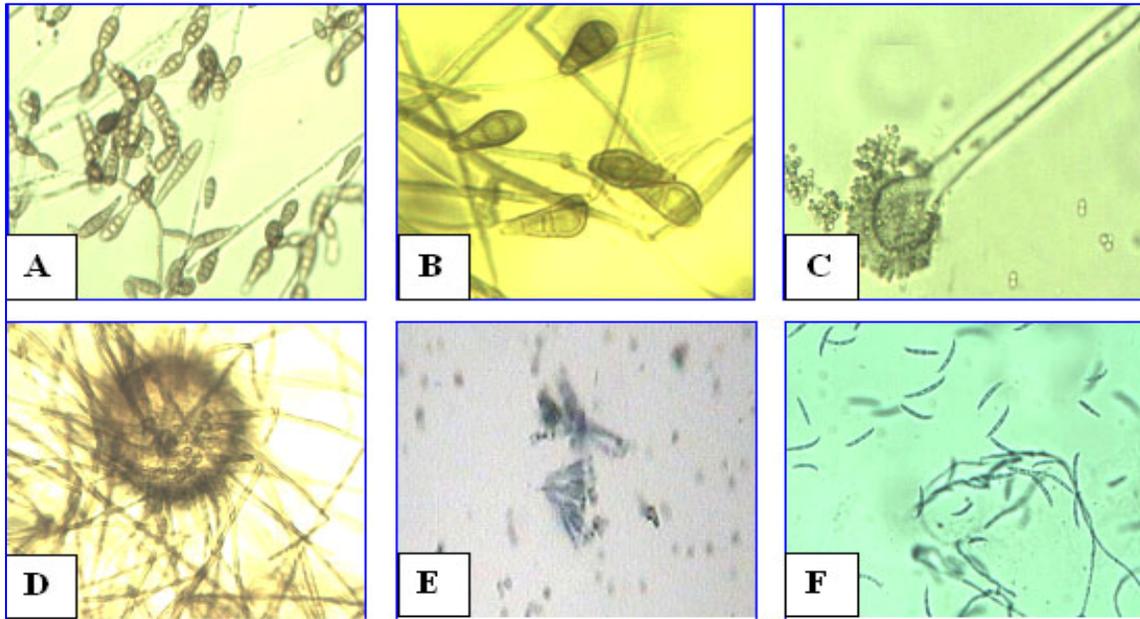
In the present investigation, twenty-three fungal species belonging to 19 genera isolated from Gwalior Fort were shown in Table 1. These fungi were *Alternaria* sp., *A. nidulans* sp., *A. fumigatus*, *A. flavus*, *A. terreus*, *A. niger*, *Beauveria* sp., *Bipolaris* sp., *Curvularia* sp., *Cochliobolus* sp., *Cladosporium* sp., *Chaetomium* sp., *Chrysosporium* sp., *Conidiobolus* sp., *Drechslera* sp., *Exserohilum* sp., *Fusarium* sp., *Penicillium* sp., *Sepedonium* sp., *Scopulariopsis* sp., *Trichothecium* sp., *Torula* sp., *Ulocladium* sp. (Figure 3). The Bhimsen Chatri, Gujri Mahal and Man Mandir sites contain the maximum number of fungal species followed by Barak, Bawari, Bahu mandir, Bhim singh Chatri, Rang Mahal, Karan mahal, Fansighar, Teli Ka Mandir, Jail, Sas mandir, Site 1, Site 2 and Vikram Mandir. Results obtained during the present investigation also revealed that *A. fumigatus*, *A. niger*, *Curvularia* sp., *Penicillium* sp., *Scopulariopsis* sp. and *Trichothecium* sp. occur relatively toward the higher side and *Alternaria* sp., *A. nidulans*, *A. flavus*, *A. terreus*, *Cladosporium* sp., *Chaetomium* sp., *Sepedonium* sp., *Torula* sp. and *Ulocladium* sp. are in the moderate range.



**Figure 1** Gwalior Fort



**Figure 2** Different deteriorating sites of Gwalior Fort.



**Figure 3** A: *Alternaria* sp., B: *Curvularia* sp., C: *Aspergillus* sp., D: *Chaetomium* sp., E: *Penicillium* sp. and F: *Fusarium* sp.

**Table 1** Fungi isolated from deteriorated stone materials.

Fungi	Habitats	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Alternaria</i> sp.		+	-	+	+	+	+	-	-	+	-	+	-	+	-	-
<i>Aspergillus flavus</i>		-	-	+	+	-	-	+	+	+	-	-	-	-	-	-
<i>A. nidulans</i>		-	+	+	-	-	+	-	-	-	+	-	+	-	+	+
<i>A. terreus</i>		-	-	-	+	-	+	-	-	-	-	+	-	-	-	-
<i>A. niger</i>		-	-	-	+	-	-	-	+	-	-	+	-	-	-	+
<i>A. fumigatus</i>		-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Bipolaris</i> sp.		+	-	-	-	+	+	-	-	-	-	-	-	-	-	-
<i>Beauveria</i> sp.		+	-	+	+	-	-	+	-	-	-	-	-	-	-	+
<i>Chaetomium</i> sp.		-	-	-	-	+	-	-	-	-	+	+	-	-	+	-
<i>Cladosporium</i> sp.		+	+	-	-	+	+	+	-	+	-	-	-	+	-	-
<i>Curvularia</i> sp.		+	+	+	-	+	+	-	-	-	-	+	+	+	+	+
<i>Cochliobolus</i> sp.		-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Conidiobolus</i> sp.		-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Chrysosporium</i> sp.		-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Drechslera</i> sp.		-	+	+	-	+	-	-	-	-	-	-	-	+	-	-
<i>Exserohilum</i> sp.		-	+	-	-	-	+	-	-	-	+	+	-	-	-	-
<i>Fusarium</i> sp.		-	-	-	-	+	+	-	+	-	-	-	+	+	-	-
<i>Penicillium</i> sp.		-	-	+	-	-	+	+	+	+	+	-	-	-	+	-
<i>Scopulariopsis</i> sp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Sepedonium</i> sp.		-	+	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Torula</i> sp.		-	-	-	-	-	-	+	-	-	-	+	-	-	-	-
<i>Trichothecium</i> sp.		-	+	-	+	-	-	-	-	-	+	-	+	-	-	-
<i>Ulocladium</i> sp.		-	-	-	+	+	-	-	+	-	-	-	-	-	+	-

1- Barak, 2- Bawri, 3-Bahu Mandi, 4- Bhimsen Chatri, 5- Gujri Mahal, 6- Man Mandir, 7-Rang Maha, 8- Karan Mahal, 9-Fasighar, 10- Teli Ka Mandir, 11- Jail, 12-Sas Mandir, 13- Site 1, 14- Site 2, 15-Vikram Mandir (+ Present & - Absent).

#### 4. DISCUSSION

The mentioned fungal species are typically soil fungi, which is in accordance with the results of ref. [15] who noted a considerable number of the same genus and species. The identified microfungi cause discoloration as well as mechanical exfoliation of stone material that was analyzed through mechanical hyphae penetration and production of different pigments (*Cladosporium* sp. and *Alternaria* sp.) and organic acids (some species of genus *Aspergillus* sp., *Alternaria* sp. and *Penicillium* sp.). Refs [15, 16] 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. This collaboration is the comparative study of the role of microbial colonization on the degradation of historic monuments [17, 18].

#### 5. CONCLUSIONS

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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