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THE DISTRIBUTION AND DIVERSITY OF FUNGI AND MACROFLORA ON THE TEMPLE GROUPS OF KHAJURAHO (M.P)

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ABSTRACT

Khajuraho is known for their art and beautiful artwork internationally. This beautiful place is located in the Chhatarpur district of Madhya Pradesh, India. Total 21 temples are surviving in the present out of 84 temples. The open exposure of the temple to the environment causes discoloration and ugly look of the temple. It has been observed during the study on the temple, several species of fungi and higher plant species like grasses and weeds cause the damage and deterioration of the temple. Different fungal flora like Alternativa alternata, Aspergillus niger, A. flavus, A. fumigates, Chitridium sps., Culvularia lunata, Fusarium oxysporium, Rhizopus vigricans, and Mucor sps. etc. isolated. Also found in various macroflora like Amaranthus viridis, Auria scandence, Beorhaavia diffuse, Bothriocloa pertusa, Cassia tora, Cynodon dactylon, Euphorbia hirta, Ficus religiosa, Ficus benghalensis, Indigofera sps, and Oxalis trifolia etc. identified and calculated similarity, dissimilarity index and frequency of flora in the present study. The present research work mainly focused on the distribution and diversity of the Eastern group of temples and Southern group of temples at Khajuraho.

KEYWORDS: *Khajuraho, Deterioration, Discoloration, Fungi, Macroflora*

INTRODUCTION

The process of deterioration is generally a natural process. It is directly related to the abiotic factors such as light, temperature, humidity, rain, moisture etc. and anthropogenic factors. These all the factors are basically required for all living things to live. That's why it can't be called as a separate phenomenon from natural processes. Khajuraho monuments are situated in the central part of Bundelkhand region of Madhya Pradesh India. The latitude and longitude of Khajuraho is $24^0$4950' N and $79^0$5502' E respectively. The Vindhyan range of mountain runs through it where climatic conditions provide support for the growth of various biological elements and both biotic and abiotic conditions are lead to damage and deterioration of the temples. A wide variety of micro-organism like bacteria, fungi, algae, lichen and macro-organism like bryophytes, pteridophtes and some higher taxa like grasses and weeds played major role in the process of damage and deterioration.

The khajuraho temples are famous for their beautiful art and sculpture of 9^{th} and 11^{th} century. From the ancient period, these temples are directly exposed to face the climatic conditions and fluctuations. Different microbial agencies create their own climate by reaction with abiotic factors and from their shelter to live. This process of damage can be relate with a succession process of formation of soil from rock substrate. Khajuraho temples were made by sandstone without the use of mortar. Sandstone is porous in nature due to its porosity it accumulates more water in its cavity. The property of

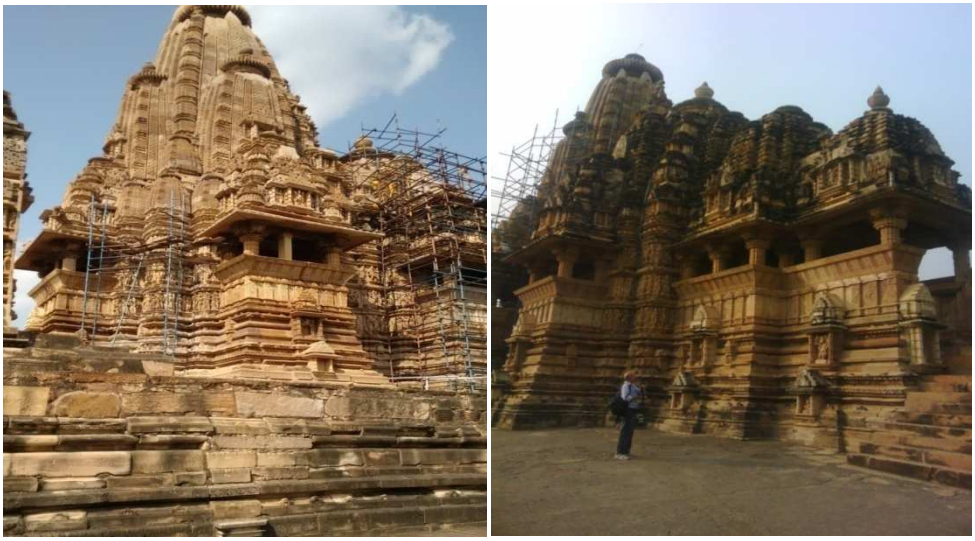
water accumulation make, it is easy to grow micro and macro biological elements. According to many researchers, members of algae like cyanobacteria and chlorophyta firstly start the process of colonization on surface of the temple (Bhavani et al. 2013; Cecchi et al. 2000; Lomenti et al. 2000; Ortega et al. 1991; Croispim and Gayralde 2005; Gaylarde and gaylarde 2000; Tiano et al. 1995 and Tomaselli et al. 2000). Some researchers have studied that the lichens are leading the pioneering on the monumental surface because they can live in extreme condition of the environment and extract nutrition from stone (Smith et al 1987; Bjelland et al. 2002; Huneck et al. 1986). According to Mecedo et al. (2009) successive growth of various microorganisms on stone is the result of many ear decomposition. Isolation of various species of bacteria, fungi, algae, cyanobacteria etc is done by many scientists (Urzi et al. 1991; danin and Caneva 1990; Lomenti et al. 2000)

Various species of fungal flora attacks mainly on the weakest part of stone temple and forms their colonies (Sterfinger and Krumbein 1997). Due to weathering, decomposed material of microorganism provides suitable conditions for fungi to grow and colonize on surface of the temple. Different species of fungi have been counted from weathered stone of monuments by many research workers Sharma B.R.N., Chaturvedi K., Samadhia N.K. and Tailor P.N. 1985).

Some fungal species like *Penicillium*, and *Cephalosporium* have large potential of (mycotoxins) biochemical damage in comparing to Lichen (I.K. Isskandar and J.K. Syers 1972). Common fungi like *Cladosporium*, *Penicillium*, *Trichoderma*, *Fusarium and Phoma* are investigated as abundant species on temple surface (Eckhadt F.E.W. 1980; De La Torre, et.al. 1991). That has been demonstrated that fungi can accelerate the exfoliation of the stone crust because they are chiefly involved in crust formation as well as the formation of rock varnish (Krumbein, W.E., Grote, G. and Peterson, K. 1986).

The growth and radial thickenings of the higher plant species lead the biophysical and biochemical damage of monuments (Winkler E.M. 1975). When higher plant species grow on monumental surface, their well developed root system can penetrate deep into the cracks and drifts of monuments cause direct detachment of large particle of stone from the monuments (Caneva G., Altieri A. 1988; Riederer J. 1981, Siswowiyanto S. 1981). The development of micro and macro flora is very harmful to the stone temple in tropical climates where climatic conditions like heavy rainfall and fluctuation in the temperature greatly increase the growth of micro vegetation and macro vegetation.(Tiano P., Caneva G. 1987; Fusey P. and Hyvert G. 1966). The penetration of roots deeply into the compact substrata is playing major role in the physical damage of monuments. The rupicolous species like *Capparis spinosa* is able to reach several meters (10 - 20) deep into a very hard surface (Riedier J. 1984).

The aim of the present work is to study and calculate the distribution and diversity of fungi and macroflora like grasses and weed species using myco-ecological parameters and microscopic observations to calculate the frequency and similarity index and damage cause by different species of fungi and higher plant species.



(A) **(B)**

(C) **(D)**

Figure 1 (A) & (B): Temples of Eastern Group of Temple, (C) and (D) Temples of Western Group of Temple

MATERIALS AND METHODS

Sampling and Isolation of Fungi: Total 10 samples were collected from each community, namely an eastern group of temple (community A) and southern group of temple (B). Located at Khajuraho is the small village of Chhatarpur district of Madhya Pradesh. Collected sample were brought to an aseptic condition to the laboratory. The isolation of microorganism was done by culture method with direct sterilization of samples in the incubation chamber. Growth of fungal colony was observed on Potato Dextrose Agar medium plates in 7 days of incubation period at 28^0C and examined daily for the growth rates and sporulation, the various isolated fungal colonies were transferred into fresh PDA plates the procedure was continuously repeated for 5 times to remove the impurities. The purified fungal culture were identified with mycological techniques and compared with the available authentic literature, review and mycological manuals.

Macro Floral Study: The macro floral study of higher taxa is done by the quadrate method of collection. Total 10 quadrate was studied at the each community site. Total 17 species were collected from community A and 12 species were from the community.

Calculations: Different ecological characters of micro and macro flora are done by following equation:

$$\% \text{ Frequency (F)} = \frac{Number\ of\ samples\ in\ which\ species\ present}{Total\ number\ of\ sample\ studied} \times 100$$

Index of Similarity (SI) = 2C/ A+B

Where A= Total species in community A

B= Total species in community B

C= Common number of species in community A and B

Observation Table

Table 1: Isolated Microflora from Temple Group

S.No	Name of species	Community A												
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	F%	SI	DI
1	*Alternaria alternate*	+	+	+	+	+	+	-	+	+	+	90%		
2	*Aspergillus niger*	+	+	+	-	-	+	+	-	-	+	60%		
3	*A. flavus*	-	+	+	-	+	-	-	+	+	+	60%		
4	*A. fumigates*	-	+	-	-	-	+	+	+	-	-	40%		
5	*Chitridium sps.*	+	+	-	+	-	-	+	+	-	-	50%		
6	*Culvularia lunata*	+	+	+	-	+	+	+	-	-	+	70%		
7	*Fusarium oxysporium*	+	-	+	-	-	+	+	-	-	+	50%		
8	*Mucor sps*	+	+	+	+	+	+	+	-	+	+	90%		
9	*Penicillium sps.*	+	+	-	-	+	-	+	+	-	-	50%		
10	*Rhizopus vigricans*	+	-	+	-	-	+	+	+	-	-	50%		
11	*Trichoderma viride*	-	+	+	+	-	+	-	-	+	-	50%		
	Community B													
1	*Alternaria alternate*	+	+	-	-	-	+	-	+	+	-	50%		
2	*Aspergillus flavus*	-	+	+	+	-	+	-	-	+	-	50%		
3	*A. fumigates*	-	+	+	-	-	-	+	+	+	-	50%		
4	*Culvularia lunata*	+	+	+	+	-	-	+	-	-	+	60%		
5	*Fusarium oxysporium*	+	-	-	-	+	+	+	-	+	-	50%	0.77	0.23
6	*Rhizopus vigricans*	+	+	+	+	-	-	+	+	+	-	70%		
7	*Mucor* sps.	+	+	+	+	+	+	-	-	+	+	80%		
Total number of common species between Community A and B = 7														

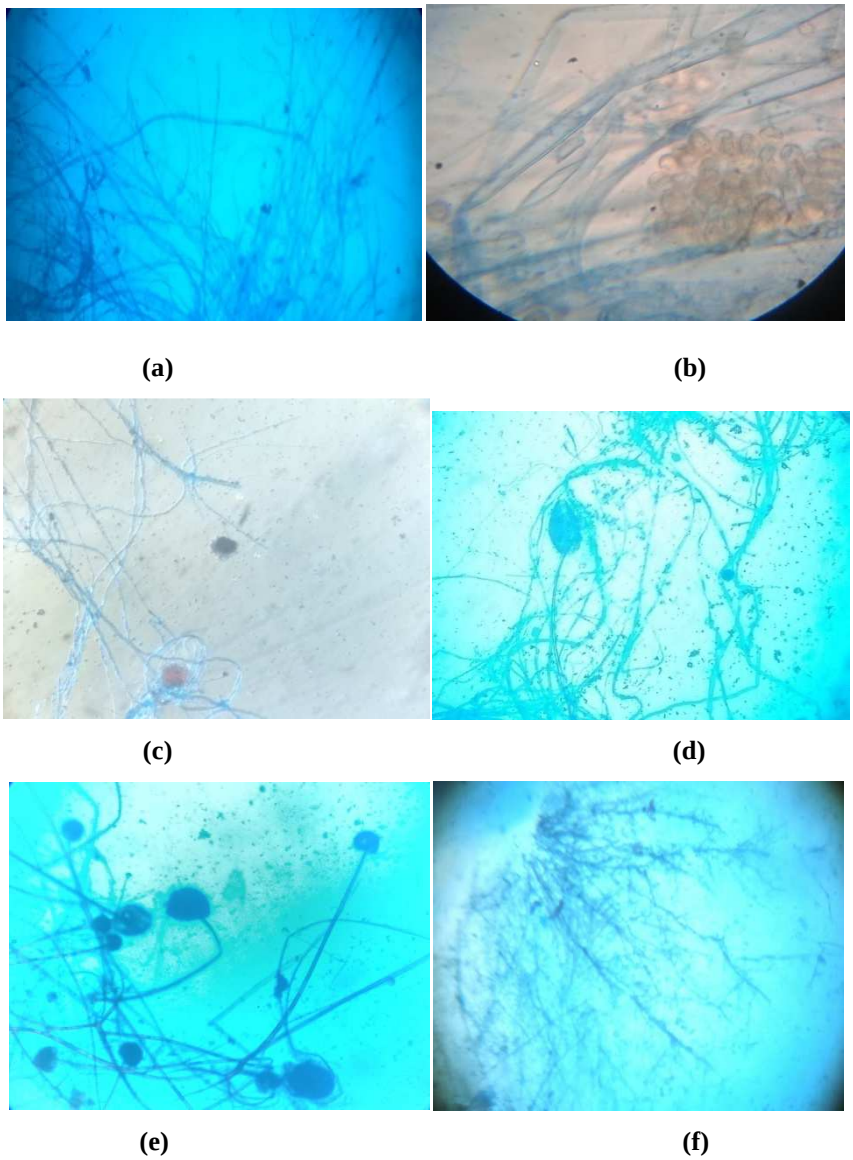
Table 2: Observed Macro Flora from Temple Group

S.No	Name of species	Community A												
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	F%	SI	DI
1	*Alicicarpus monolifer*	-	-	-	-	+	+	+	-	-	-	30%		
2	*Amaranthus viridis*	+	+	-	-	+	+	-	-	+	+	60%		
3	*Auria scandence*	+	+	+	-	-	-	+	+	+	-	60%		
4	*Boerhaavia diffusa*	-	-	-	+	+	-	-	+	+	-	40%		
5	*Bothriocloa pertusa*	-	+	+	+	+	+	-	+	+	+	80%		
6	*Cassia tora*	-	-	-	+	+	-	-	-	+	+	40%		
7	*Cynodon dectylon*	+	+	+	+	-	+	-	+	+	+	80%		
8	*Euphorbia hirta*	+	+	+	-	+	-	+	+	-	-	60%		
9	*Ficus benghalensis*	-	-	-	+	-	-	-	+	-	-	20%		
10	*Ficus religiosa*	-	-	+	-	-	-	+	+	-	-	30%		
11	*Indigofera asterogalina*	+	+	+	-	-	+	-	+	+	+	70%		
12	*Oxalis trifolia*	-	+	+	-	-	+	+	+	-	+	60%		
13	*Parthenium sps.*	-	-	-	+	+	-	-	-	-	+	30%		
14	*Phyllanthus niruri*	+	+	-	-	+	-	+	-	-	-	40%		
15	*Sida acuta*	-	-	-	-	+	-	-	+	-	-	20%		
16	*Sporobolus indicus*	+	+	+	-	-	-	-	+	+	+	60%		
17	*Tridex procumbens*	+	+	+	+	-	-	+	-	+	+	70%		
	Community B													
1	*Auria scandence*	+	-	-	+	-	+	+	+	-	-	50%		
2	*Bothriocloa pertusa*	+	+	+	+	-	-	+	+	+	-	70%		
3	*Cassia tora*	-	-	+	+	-	-	+	-	-	-	30%		
4	*Cynodon dectylon*	+	+	+	-	-	+	+	+	+	+	80%		
5	*Euphorbia hirta*	+	+	-	-	+	+	-	-	-	+	50%		
6	*Ficus religiosa*	-	+	-	-	-	-	+	-	-	-	20%		
7	*Indigofera asterogalina*	+	-	-	+	+	-	-	-	+	+	50%	0.82	0.18
8	*Oxalis trifolia*	-	-	+	-	+	+	+	-	-	+	50%		
9	*Parthenium sps.*	+	-	+	-	-	+	+	-	-	-	40%		
10	*Phyllanthus niruri*	+	+	-	-	+	-	-	+	+	+	60%		
11	*Sporobolus indicus*	+	+	-	-	+	+	+	+	-	-	60%		
12	*Tridex procumbens*	-	-	+	-	+	+	+	-	-	+	50%		
Total common species in community A and B = 12														

RESULTS AND DISCUSSIONS

Total 11 species of fungi and 17 species of higher plant species were observed in the collected sample of eastern group of temple while 7 species of fungi and 12 species of higher plant species found in the sample of southern group of temple of Khajuraho (Table 1,2). Combine study reveals that all 10 samples of fungi were mainly dominated by various species of fungi like *Alternaria alternata*, *Mucor* sps., *Culvularia lunata*, and *Rhizopus vigricans* due to their higher frequency. *Alternaria alternata* and *Mucor* species have shown the maximum frequency followed by *Culvularia lunata*, *Rhizopus vigricans*, *Aspergillus flavus* and *A. niger* in the sample of Eastern group of temples and the 10 samples from the southern group of temple shows the maximum frequency of *Mucor* sps. followed by *Rhizopus vigricans* and *Culvularia lunata*. On the other hand in the study of macroflora *Cynodon dactylon* and *Bothriocloa pertusa* found frequently followed by *Indigofera*, *Tridex procumbens*, *Amaranthus*, *Auria scandence*, *Euphorbia hirta* and *Oxalis trifolia* in the community of Eastern group of temple and in the macrofloral community of southern group of temple *Cynodon dactylon* was found frequently followed by *Bothriocloa pertusa*, *Phyllanthus niruri* and *Sporobolus indicus*.

Value of similarity index 0.77 of fungal flora and 0.82 of macroflora concluded that the various species of fungi and macroflora shows the maximum similarities between community A and community B with reference of the different sample from the each site either of macroflora or of fungal flora. From the dissimilarity point of view fungal flora found with the value 0.23 of dissimilarity and macroflora observed with 0.18 values of dissimilarity between them. This observation of study revealed that the distribution and diversity is mainly common in both communities lead the process of deterioration.



(a) **(b)**

(c) **(d)**

(e) **(f)**

Figure 2: Microscopic View of Different Fungi (a) Culvularia, (b) Penicillium, (c) Aspergillus, (d) Mucor, (e) Rhizopus, (f) Chytridium

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