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Impact of fungi on historical monument with reference to Mahadev temple Bastar of Chhatisgarh

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Abstract

Materials of built heritage are at risk of bio-deterioration caused by diverse populations of microorganisms living in biofilms. The microbial metabolites of these biofilms are responsible for the deterioration of the underlying substratum and may lead to physical weakening and discoloration of stone. Fungal ability in production of pigments and organic acids have crucial role in discoloration and degradation of different types of stone in cultural heritage objects. Additionally, stone objects may support novel communities of microorganism that are active in bio-deterioration process this investigation focused on mycological analyses of microbial biofilm from Mahadev temple, Bastar of Chhattisgarh state which is made of sand stone and which were heavily colonized by fungi. The eight fungal species on sand stone were isolated. Aspergillus sp. was common in stone structure. 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.

Keywords: Bio-deterioration; Microorganisms; Biofilms; Pollutants; Microbial metabolites; Pigments

1 Introduction

1.1 Historical importance of the Mahadev Temple, Bastar

Chhattisgarh is a land of surprises with a lot to offer for everyone. In the southern part of the state, there is a pristine place untouched by the hustle-bustle of city life, with serenity all around – Bastar. Bastar is a division of seven districts. It is interesting to note that there's a divison, a district and a village named Bastar too. Bastar is known for its natural beauty, but it is equally rich in architectural beauty.

It is believed that the Kakatiya rulers before moving to Jagdalpur, stayed in a town for a shorter period of time. This town or place where they stayed was later named as Bastar and thus it got its name. In the Bastar village itself, a temple has been constructed, but by whom still remains a question unanswered. Hence, the temple stands as an archaeological site which is very old and ancient. The temple has two chambers within, one is to offer prayer and the second room is for Garbha Griha where the Shiva Ling is centrally located. The temple is beautifully constructed with two idols as gate keepers kept at the entrance of the Garbha Griha. The temple is popularly believed for some ancient beliefs and rituals by the people especially by the married couples who do not have children. The couple prays within the temple and wishes for one, when the wish is fulfilled they offer silver image of snakes and other material. The temple is hugely crowded by the people from nearby and distant areas to fulfill their wishes and to seek blessings.

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Since, the temples are worship areas hence they are flooded with visitors and pilgrims all throughout the year. The temples are mostly the areas wherein people can find peace and dwell into spirituality. Hence, devotees are always welcomes to the temple premises. Might this not be a different place of visit for Indians, but it is for people who are not from India. In fact, every temple has its own origin and is a must visit by any human. But due to microorganism and others environmental factors, surface of the temple is deteriorating.

1.2 Cause of deterioration

Microorganisms contribute to the deterioration of stone artifacts such as historical monuments and statues[1]. The oxalic and citric acids excreted by various fungi act as a chelating agent thereby leaching the metabolic cations from the stone surface. Oxalic acid causes extensive corrosion of primary minerals and the complete dissolution of ferruginous minerals through formation of iron oxalates and silica gels[2-3]. Fungi are a group of heterotrophic organisms that have been detected systematically on degraded stone buildings in tropical and temperate regions[4-5]. They may have greater deteriogenic potential than bacteria, as they produce and excrete higher concentrations of organic acids[6]. In addition, these microorganisms may cause physical biodegradation of stone by the growth of hyphal networks through the pore space system[7]. We studied the deterioration of ancient stone buildings at the archaeological site of Mahadev temple, which is located in small village called Bastar which is 25 km away from head quarter Jagdalpur city of Chhattisgarh state and investigated the frequency and their class of the fungal species to produce acid-linked degradation of the stone.

The Mahadev temple massive in character was dedicated to lord Shiva. The entrance part of the temple is adorned with beautifully carved scenes such as the marriage of shiva and parvati, the scene depicting the amusement of ganas in the said occasion, life size images of Ganga and Yamuna etc. the temple can be dated to 6th -7th century AD.

2 Material and methods

2.1 Sampling and Isolation of fungi

Totally 10 Samples were collected from various places of the Mahadev temple at Bastar of Chhattisgarh state and 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 chamber8. Two different agar media were taken for the selection of basal media. Media employed were Czapeck-Dox and Potato dextrose agar. Out of two media Czapeck's-Dox medium was selected as the basal medium for subsequent studies, because this medium supported good mycelial growth and excellent sporulation for all the best organisms and its composition is simple due to which modifications and substitution of various ingredients were possible. The purified fungal cultures were identified by using mycological techniques and were compared with the available authentic literature, reviews and mycological manuals9-12.

Table 1 Occurrence, percentage frequency and class of different Fungal species in Mahadev temple at Bastar

Isolated fungi	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Frequency (%)	Frequency Class
Aspergilus niger	+	+	+	+	+	+	+	+	+	+	100	C
Aspergillus sydowi	+	+	+	+	+	+	-	+	+	+	90	C
Aspergillus nidulans	+	+	-	-	+	+	+	+	+	+	80	C
Aspergillus terrus	+	+	-	-	+	+	+	+	+	+	80	C
Helminthosporium Velutinum	+	+	+	-	+	+	+	-	-	-	60	F
Mucore sp.	+	-	-	+	-	-	+	-	+	-	40	O
Cladosporium	+	+	+	-	-	+	-	+	+	+	70	F
Penicillium chrysogenum	+	-	+	-	-	+	-	-	+	+	50	O

(+) = presence of species; (-) = absence of species; C = common; F = frequent; O= occasional

2.2 Percentage of frequency

Frequency occurrence was calculated as follows:

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

Based on the frequency occurrence the fungi were grouped as Rare (0-25% frequency), Occasional (26-50% frequency), Frequent (51-75% frequency), and Common (76-100% frequency) species.

3 Results and discussion

Eight species of fungi was isolated during the investigation period from the monument (Table 1).Fungal species was found in a biofilm where their effect on the stone substrate led to the deterioration of the monument. This community forming thick biofilms produced intense pigmentation varying from dark green to dark red which altered the aesthetic appearance of the stone.

3.1 Substrate features, environmental conditions and growth of fungus

Climatic factors on stone monuments in dry areas may not favour the growth of lichens but allow the colonization of fungi. In the study site fungi are the dominant microorganisms and they are the most harmful microorganisms that cause bio-deterioration of organic and inorganic materials. The substrate features and environmental conditions suitable for fungi. In penetration phase fungus extends its hyphae into the inner part of the stone and establish as larger colonies. In the present study in many locations on the surface and crevices of the stone structures many pits were observed. Earlier researcher[13] have reported that the design of buildings give some implications on the weathering of the surfaces and that the attack by microbes follows the initial physical and chemical weathering and that weathering is more rapid when microbes are involved. In the present study *Aspergillus* species are the most common species and *Aspergillus niger* is the most dominant fungal species found in the sites. The grey and black colour of the stone surfaces is not only due to dematiceous fungi but very frequently it is due to the endolithic phototrophic microorganisms like cyanobacteria and algae. The results of the present investigation concur with various works done by researchers and proved that excessive moisture in building materials supports microbial growth[14]. Endolithic lichen and fungal growth can be used to describe the ecophysiological adaptation thereof to the environmental extremes of the rock as studied[15]. Hence study of distribution patterns and colonization patterns are essential in formulating conservation works. The characterization of these microorganisms and a clear understanding of their role in the process of stone decay are essential for suitable restoration interventions.

Figure 1 Front view, Lateral view and cross section of Mahadev temple, Bastar of Chhattisgarh showing fungal growth on the surface of Monument

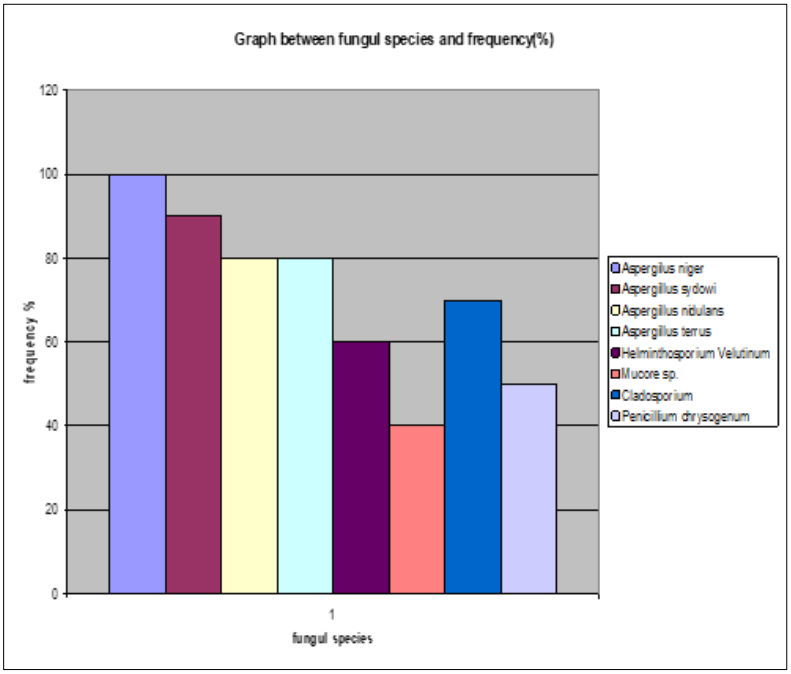

Figure 2 Graph between % frequency and isolated fungal species

4 Conclusion

Climatic factors on rock and stone monuments in dry areas may not favor the growth of lichens but allow the colonization of fungi. The substrate features and environmental conditions suitable for algae are also suitable for fungi except that they need additionally some organic nutrients and perhaps the initial algal growth and decay of stone to some extent helps/aids in the successive growth of fungi. Air borne fungi fail to settle on polished surfaces but the fungal hyphae can easily penetrate the porous and rough surfaces of the stone monuments. Though crevices are the favored places, under optimal environmental conditions they colonize the entire surface as seen in monument (Fig. 1). Earlier researcher reported that fungus first settles on the weakest zone of the stone surface whereby stating that bio-receptivity is the essential prerequisite of the stone to be colonized. In penetration phase fungus extends its hyphae into the inner part of the stone and establish as larger colonies. Earlier researcher have also reported that the design of buildings give some implications on the weathering of the surfaces and that the attack by microbes follows the initial physical and chemical weathering and that weathering is more rapid when microbes are involved. Hence the studies of distribution patterns and colonization patterns are essential in formulating preservation and conservation works. The characterization of these microorganisms and a clear understanding of their role in the process of stone decay are essential for suitable restoration interventions.

Compliance with ethical standards

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Disclosure of conflict of interest

Certified that authors have no conflict of interest and also certified that the article is the authors original work.

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