FUNGAL DETERIORATION OF SANDSTONE STRUCTURE AND THEIR SCIENTIFIC PRESEVATION WITH REFERENCE TO HISTORICAL MONUMENT KALA DERA-I TEMPLE OF JAMMU & KASHMIR STATE (INDIA)

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Abstract:

Stone objects may support novel communities of microorganisms that are active in 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 10 samples were collected from different sites of Kala Dera-I temple of Jammu and Kashmir State. The five (05) fungal species were isolated which have dominance over sandstone structures of the monuments. During investigation period it was observed that *Aspergillus sp.* was found most dominant followed by *Rhizopus sp.* 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.

Key words:- Degradation, Deterioration, Sandstone monument, Micro-flora, Bio-film.

I. INTRODUCTION

There are numerous monuments in Udhampur District of Jammu & Kashmir State (India). Kala Dera – I temple is one them which is located at Manwal and is assignable to circa 10th century AD. The temple is built on a high platform and preceded by a mandapa (Fig: A & B). The entrance is through a flight of step on the east (Fig-C). The superstructure is missing. The temple is on the high platform (Fig-D), two jambs of the sanctum, the entrance way to the mandapa and the bases of four columns. The jambs of the entrance to the sanctum have two niches each with arched tops. Between the sanctum and the mandapa is a porch which also contains two smaller pillar bases. The four massive fluted columns have recently been fixed on their bases. Externally the sanctum has both plain molding and geometrical designs. The wall of the basement has recently been concerned. The noteworthy architectural members, lying at the site are fluted shafts, carved ceiling with inverted lotus flowers, pedestal of images and pillar bases, besides two sculpture of dancing Siva, now exhibited in the sculpture shed (S.A., 2012).

During the recent decades there has been a general concern about the deterioration of historical monuments. Numerous factors affect the 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 (Fig:E&F) (Gupta, *et al.,*2015).

Fig (A): General view of Kala Dera temple-I

Fig (B): Lateral view of Kala Dera temple-I

The microbial metabolites of bio-films are responsible for the deterioration of the underlying substratum and may lead to physical weakening and discoloration of sandstone (Gupta *et al.,* 2012). The condition of the monuments depend on use of them, also plays a vital role, which deteriorate the monuments. The development of specific species on a particular stone surface is

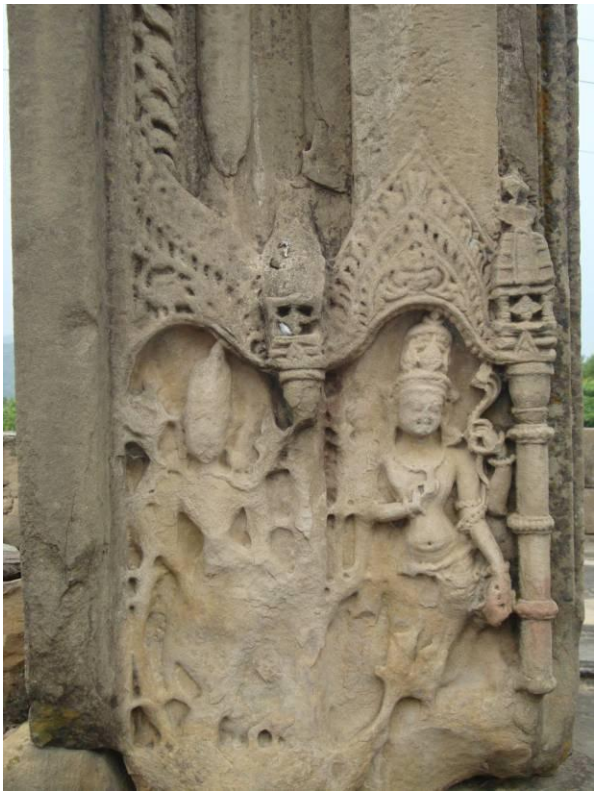
determined by the nature and properties of the stone. The response of living organism to a potentially colonizable surface depends on ecological species involved (Kumar and Kumar, 1999).

Fig (C): Frontl view of Kala Dera temple-I

Fig (D): Side-Lateral view of Kala Dera temple-I

Microorganisms participate actively in the weathering of minerals (Banfield and Hamers 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 *et al.,*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 condition.

The aim of this work is to study the micro fungi community on monuments by using myco-ecological parameters and microscope observations in order to evaluate the importance value index and damage caused by fungal species (Gupta, *et al.,*2015).



(E):Frazile Sculpture of Kala Dera temple-I **(F): Deteriorated Stone structure of Kala Dera temple-I**

Conservation Issues

The Kala Dera-I temple was 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 deposits, the aesthetic beauty of the temple is seriously affected. From a scientific point of view, these depositions are very harmful for the health of the stone surface, because these micro organisms secrete an acid that dissolves the sand stone (Gupta and Sharma, 2011).

II. MATERIAL AND METHODS

a- Sampling and Isolation of Fungi

A total of 10 Samples were collected from various locations of Kala Dera-I temple and brought to the laboratory under aseptic conditions. The isolation of micro- organisms was done by culturing the samples [Fig:G(a-e)] and by direct incubation of samples in moist chamber. The purified fungal cultures were identified by using mycological techniques and were compared with the available authentic literature, reviews and mycological manuals (Alexopoulus, 1978; Barnett &

Hunter, 1987; Ellis, 1976 and Gilman, 1995 and Gupta, *et al.,*2015).

b-Calculations

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

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

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

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

OBSERVATION TABLE - 1

Isolated fungi	Culture plates										F %	D	Ab
	P 1	P 2	P 3	P 4	P5	P6	P7	P 8	P9	P1 0			
Aspergillus fumigates (**Fresenius.**)	1	-	-	2	-	-	1	-	-	-	30	0.4 0	1.3 3
Aspergillus niger (**Tieghem.**)	-	6	-	4	1	6	-	-	5	2	60	2.4 0	4.0 0
Fusarium oxysporium (**Schlechtendahl.**)	-	-	8	2	-	-	1	-	-	1	40	1.2 0	3.0 0
Rhizopus nodosus (**Namyslowski.**)	-	-	-	-	2	-	-	-	-	-	10	0.2 0	2.0 0
Chaetomium globossum (**Kunze.**)	1	2	-	-	-	-	-	4	-	-	20	0.7 0	2.3 3

C -Removal of Dust and Dirt Accretion

Measures were taken by the Archaeological Survey of India for the removal of dust and dirt accretion to keep the stone in neutral pH and to preserve and strengthen the stone by soft brushing. The moss, fungi and lichen were removed by applying 2-3% solution of ammonia with non ionic detergent in water and by scrubbing with a nylon brush. To stop further growth of micro vegetation, 2% aq. solution of sodium pentachlorophenate was applied on the clean, dried

surface. The brittleness and powdering of stones were preserved by the application (brushing and impregnation till saturation) of an ethyl silicate based coating material, which forms a glass like silica gel binder (SiO2 aq.) with release of ethanol (by evaporation) as byproduct. Noteworthy is that the intake of stone strengthener materials was comparatively higher in the case of damaged and pulverized stones. That can be attributed to the presence of more pores for penetration. The coating of stone strengthener was applied on the deteriorated and flaky stone surface by simple brushing and impregnation till saturation (Gupta and Sharma, 2011).

d- Preservation Solutions

It is essential that the preservation solution applied on the monuments be of good quality. It should be colorless and transparent and must not turn yellow or become colored with age, but should be fairly stable for long period of time. It should also offer reasonable protection to the monument against moisture and its film should be hard and strong enough to protect the stone surface from damaging accretions. Therefore, for the preservation of the Kala Dera-I temple silane-siloxane based compound (Wacker BS-290) was chosen, which was diluted with Mineral turpentine oil in a ratio of 1:16 and applied on the monument by soft painting brush. By using MTO as a solvent slight temporary darkening appears but preserved surface gradually get their original appearance because of slow evaporation of solvent. This compound is water proof and stops water from settling on the stone surface (Gupta and Sharma, 2011).

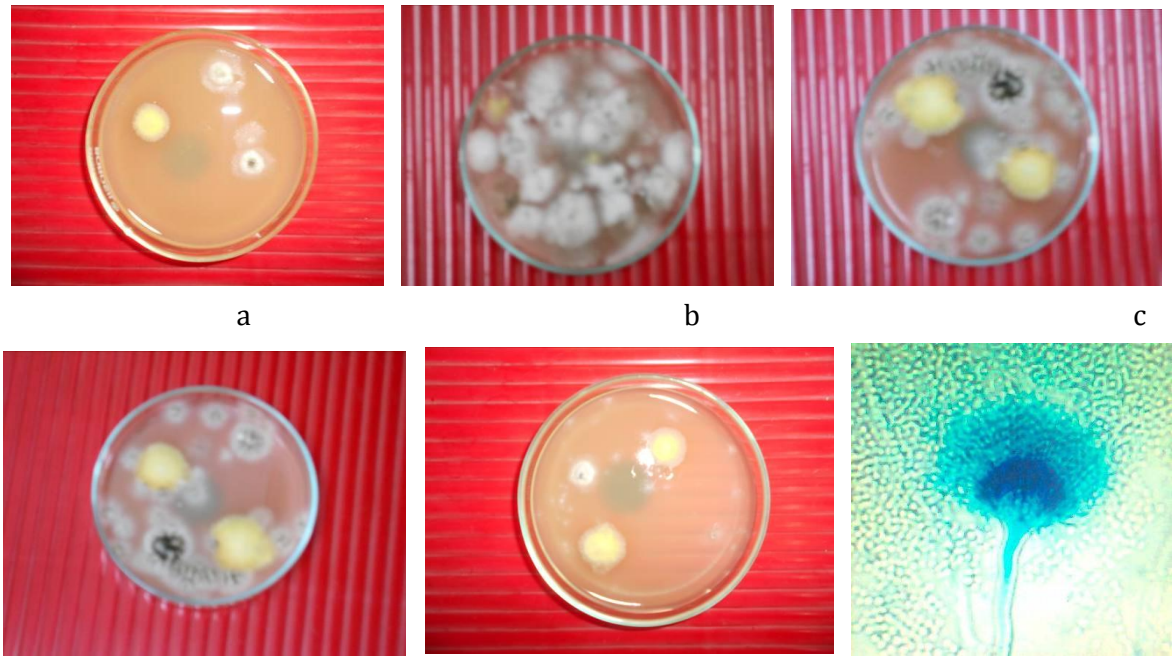
III. RESULTS AND DISCUSSION

During screening for search of mycoflora, total five species of fungal organisms were isolated from Kala Dera-I temple at Manwal (Table - 1). In the Kala Dera-I temple *Aspergillus niger* [Fig:G(f)]shows maximum frequency, Density as well as Abundance followed by *Fusarium oxysporum*. Some of the fungal species are confined to particular area i.e. *Aspergillus fumigates, Chaetomium globossum and Rhizopus nodosus* . These confinements of fungal species depend on 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 fungal organism depends upon biochemical nature of 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 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 important role in deterioration of various substrates (Gupta, *et al.,*2015).

Fig: G-Culture plate (a-e) and identified fungi (f)-*A.niger*



a b c

d e f

It has also been shown in the laboratory that fungal species such as *Aspergillus niger* 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 & Schipa, 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. Laboratory experiments have demonstrated that basic rocks are more susceptible to fungal attack than acidic rocks. In the present study *Aspergillus* are the most common species found in the sites. *Aspergillus niger* released certain metal ions from the rock samples (Boyle & Voight, 1973 and Gupta, *et al.,*2015).

IV. ACKNOWLEDGEMENT

Authors are grateful to Principal Kalyan P. G. College, Bhilainagar for providing laboratory facilities for identification of fungal species and Superintending Archaeologist, Archaeological Survey of India, Srinagar Circle, Jammu for providing necessary information related to Kala Dera-I temple and also thankful to Dr. Dilip Kumar Khamari, Superintending Archaeologist,

Archaeological Survey of India, Raipur Circle, Raipur for their proper guidance and help.

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