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RESEARCH ARTICLE

Sorenson Coefficient of Fungal Flora on Deteriorating Sandstone Structures of Historical Monument Kala Dera Temples of Jammu & Kashmir State (India)

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Abstract

After screening to search for mycoflora on two temples in Udhampur District of Jammu & Kashmir State (India) it is revealed that a total of five (05) and six (06) fungal species were found in Kala Dera-I and Kala Dera-II respectively. Two (02) fungal species namely: *Aspergillus niger* and *Fusarium oxysporium* are common in both temples. On the other hand *Aspergillus fumigatus, Rhizopus nodosus* and *Chaetomium globossum* were restricted to Kala Dera-I temple while *Aspergillus sydowi, Aspergillus flavus, Penicillium sanguifluum* and *Bipolaris sorokinianum* were restricted to Kala Dera-II temple. These confinements of fungal species depend on floristic pattern of the area. *Aspergillus niger* and *Fusarium oxysporium* shows maximum frequencies ranging from 40 % to 60 % in Kala Dera-I temple. While *Aspergillus niger, Aspergillus sydowi, Fusarium oxysporium*, and *Bipolaris sorokinianum* shows maximum frequencies ranging from 50 % to 70 % in Kala Dera-II temple. The Sorenson Coefficient has been used for comparative study of similarities and dissimilarities of fungal flora population.

INTRODUCTION

The Udhampur District of Jammu & Kashmir State (India) is known for a significant number of monuments including historical temples. Among these, Kala Dera-I & II (Fig-1&2) temples which are located in at Manwal are most visited ones. Both of these temples are assignable to circa 10th century AD. The Kala Dera- I temple is built on a high platform and preceded by a mandapa. The entrance is through a flight of step on the east and its superstructure is missing. 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. Recently four massive fluted columns have been fixed on their bases. Externally the sanctum has plain molding as well as geometrical designs. The wall of the basement has recently been constructed. The noteworthy architectural structure, 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). Another temple Kala Dera- II is also built on a raised platform followed by a mandapa and is approached by a flight of steps on the east. The roof of the mandapa has support of four fluted columns surmounted capitals. On the west side there is a makaramukha pranala through

which water used to flow into a small rectangular cistern. This part of the structure is carved out of a single block. There are two smaller entrances facing the central aisles at the rear besides the principal entrance. The figure on the jambs of the door and the porch are now defaced. The sikhara is intact on the western side. Externally the temple is adorned with plain projecting niches and offsets bearing carving. On the south-east corner, basements of the other two shrines are positioned (Gupta et. al., 2015).

Physical and chemical conditions as well as biological agents dominated in particular geographical area continuously affect the sandstone surfaces of temple monuments. Among biological agents, microorganisms are responsible for the destruction of cultural heritage (Bock and Sand 1993; Ciferri 1999). They cause damages on the stone surfaces. The damaging effects are due to formation of bio-films, chemical reactions with the substrate, physical penetration in to the substrate as well as pigment production. Numerous studies have dealt with establishing the role of biological agents in the stone deterioration (Pochon and Jaton 1968; May et al., 1993 and Gupta et. al., 2015).

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 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).

The aim of this study is to compare the fungal community populations on the monuments on the basis of myco-ecological parameters, Sorenson Coefficient of similarity, dissimilarity index and other microscope observations of damages caused by fungal species.

MATERIAL AND METHODS

Sampling and isolation of fungi

A total of 10 Samples of various locations were collected each from Kala Dera-I and Kala Dera-II temples 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 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 and Hunter 1987; Ellis 1976: Gilman 1995).

CALCULATIONS

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

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

Sorenson Coefficient (S_s) = $2a / (2a + b + c)$

Where S_S = Sorenson coefficient

a = Number of common species in both (Kala Dera I and II)

b = Number of species in first community (Kala Dera I)

c = Number of species in second community (Kala Dera II)

S_S usually is multiply by 100 (i.e., percentage coefficient) and may be also represented in terms of dissimilarity coefficient.

Dissimilarity Index (D_S) = $1 - S_S$

OBSERVATION TABLE (OT) – 1

Kala- Dera-I

Isolated Fungi	Sample Plates										Fr %
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
Aspergillus fumigates (Fresenius.)	1	-	-	2	-	-	1	-	-	-	30
Aspergillus niger(Tieghem.)	-	6	-	4	1	6	-	-	5	2	60

Fusarium oxysporium (Schlechtendahl.)	-	-	8	2	-	-	1	-	-	1	40
Rhizopus nodosus (Namyslowski.)	-	-	-	-	2	-	-	-	-	-	10
Chaetomium globossum (Kunze.)	1	2	-	-	-	-	-	4	-	-	30

Kala- Dera-II

solated Fungi	Sample Plates										Fr
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	%
Aspergillus sydowi (Thom and Church.)	2	-	1	-	1	1	-	1	-	-	50
Aspergillus flavus (Link.)	-	-	4	3	-	-	-	-	2	-	30
Aspergillus niger (Tieghem.)	-	5	2	-	8	-	6	-	-	4	50
Fusarium oxysporium (Schlechtendahl.)	1	1	-	1	-	1	-	1	1	1	70
Penicillium sanguifluum (Sopp.)	1	2	-	3	-	-	-	-	2	-	40
Bipolaris sorokinianum (Schoemaker.)	-	3	2	-	-	3	-	5	-	1	50

OBSERVATION TABLE (OT) – 2

Sorenson coefficient and dissimilarity index

FUNGAL ORGANISMS IN KALA DERA-I (b)	FUNGAL ORGANISMS IN KALA DERA-II (c)	COMMON FUNGAL ORGANISMS (a)	SORENSON COEFFICIENT $S_S = 2a / 2a + b + c$	DISSIMILARITY INDEX $D_S = 1 - S_S$
05	06	02	**0.26**	**0.74**

RESULT AND DISCUSSION

Fig -1: Kala Dera – I temple of Manwal : lateral and front view

Fig -2: Kala Dera – II temple of Manwal : front and lateral view

Total nine (09) species of fungal organisms (OT 1&2) were isolated from Kala Dera-I and Kala Dera-II of the temples of Udhampur District of Jammu & Kashmir State (India). Plates of Kala Dera-I were mainly dominated by

two fungal species i.e., *Aspergillus niger* and *Fusarium oxysporium.* While Plates of Kala Dera-II were mainly dominated by four fungal species i.e., *Aspergillus niger, Aspergillus sydowi, Fusarium oxysporium,* and *Bipolaris sorokinianum.*

Present study revealed that out of 09 fungal species, two namely: *Aspergillus niger* and *Fusarium oxysporium,* were common in both Kala Dera-I and Kala Dera-II. On the other hand three species namely *Aspergillus fumigatus, Rhizopus nodosus* and *Chaetomium globossum* were restricted to Kala Dera-I temple while four species, namely *Aspergillus sydowi, Aspergillus flavus, Penicillium sanguifluum* and *Bipolaris sorokinianum* were restricted to Kala Dera-II temple. These confinements of fungal species depend upon biochemical nature, degree of competition and prevailing environmental conditions of the area (Salvadori, 2000; Gupta et. al., 2013).

From frequency point of view, in Kala Dera-I temple *Aspergillus niger* and *Fusarium oxysporium* shows maximum frequencies ranging from 40 % to 60 % whereas *Rhizopus nodosus* shows least frequency. While in Kala Dera-II temple *Aspergillus niger, Aspergillus sydowi, Fusarium oxysporium,* and *Bipolaris sorokinianum* shows maximum frequencies ranging from 50 % to 70 % whereas *Aspergillus flavus* shows least frequency.

Sorenson Coefficient gives comparative picture of importance of fungal flora within a particular community / area. Value of Sorenson Coefficient i.e. 0.26 revealed that the studied fungal communities were significantly less similar with reference to samples collected from two different temples. On the other hand from dissimilarity point of view both the temple shows approximate 74 % dissimilarity between them. In each fungal community all the species are not equally important. Only few species exert a major controlling influence on the community and also play important role in deterioration of various substrates (Sorenson, 1948 and Gupta et. al., 2013).

In the present study *Aspergillus niger* was most frequent species found in the Kala Dera-I temple followed by *Fusarium oxysporium*. While *Fusarium oxysporium* was most frequent species found in the Kala Dera-II temple followed by *Aspergillus niger, Aspergillus sydowi* and *Bipolaris sorokinianum.*

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