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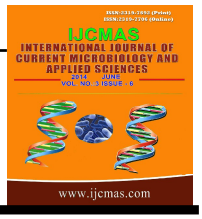

Original Research Article

Indexing of Importance value of Micro flora on Sandstone Monuments at Narayan Temple, of Chhattisgarh, India

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A B S T R A C T

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 Narayan pal temple of Chhattisgarh State. The five (05) fungal species along with one (01) Bryophyta member were isolated which have dominance over sandstone structures of the monuments. During the investigation period it was observed that Aspergillus sp. was found most dominant in all the three relative values as well as IVI followed by Rhizopus vigricans and Curvularia lunata respectively. 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

Degradation, Deterioration, Sandstone monument, Micro-flora, Biofilm.

Introduction

During the recent decades there has been a general concern about the deterioration of historical monuments. There are numerous monuments in Bastar District of Chhattisgarh state. One of such monuments, the Narayan temple at Narayan Pal (Fig-1) and is highly affected by Naxlite activities.

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.

Narayanpal is located on the banks of the Indravati river, at distance of 40 kms from Jagdalpur. It is known for two temples –one dedicated to Vishnu temple and other to Bhadrakali. Originally, dedicated to Shiva, the Vishnu temple was later modified to house its present deity. To day, only the garbhagriha and beautifully crafted shikhara are extant. Both the Vishnu and the Bhadrakali temples are excellent examples of 11^{th} century temple architecture (Mitra, 2008). Narayan temple, Narayanpal is east facing temple. This east facing nirandhra temple dedicated to Lord Vishnu stands on large platform. It has an imposing curvilinear sikhra. The temple is saptaratha on plan and datable to circa 12^{th} -13^{th} century A.D. (Mishra et. al, 2012).

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). 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.

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.

Materials and Methods

Sampling and Isolation of fungi

A total of 10 Samples were collected from various locations of Narayan Pal temple of Bastar district 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 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).

Calculations

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

$$\textbf{\% Relative Frequency (RF)} = \frac{\text{Frequency of individual organism}}{\text{Total Frequency of all organisms}} \times 100$$

$$\textbf{\% Relative Density (RD)} = \frac{\text{Density of individual organism}}{\text{Total Density of all organisms}} \times 100$$

$$\textbf{\% Relative Abundance (RA)} = \frac{\text{Abundance of individual organism}}{\text{Total Abundance of all organisms}} \times 100$$

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Abundance

Results and Discussion

During the screening for search of mycoflora, total five species of fungal organisms and one species of Bryophyta (moss) were isolated from Narayan Pal temple (Table - 1). Composite result indicate that in all the ten (10) samples were mainly dominated by different species of *Rhizopus vigricans*, *Aspergillus niger* and *Aspergillus flavus* due to their high percentage relative values.

Aspergillus niger shows maximum relative value followed by *Aspergillus flavus* and *Rhizopus vigricans*. Some of the fungal species are confined to particular area. These confinements of fungal / Moss species depend on environmental conditions of the area, which varies from geographical area to area. Earlier researcher 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 (Eckhardt, 1988).

Importance value index of a species in the community gives the idea of its relative importance. Study of Importance value index revealed that the *Aspergillus niger* shows maximum IVI value (84.3) followed by *Aspergillus flavus* (64.4), *Rhizopus vigricans* (56.3) and Curvularia lunata (46.0) respectively. On the other hand *Trichoderma viride* and *Funaria hygrometrica* (Moss) shows least IVI value. 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 also play important role in deterioration of various substrates. 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. The capacity of fungi to dissolve carbonates depends on available carbon sources, such as oxalic and citric acids which may mobilize cations with chelating activity. Fungi are an important constituent of microbial endolithic assemblages in moist ecosystem (Golubic et.al, 2005). 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).

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. 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). 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).

Fig.1 Narayanpal Temple (showing deposition of biological agencies on the surface): a & c-lateral view, b-back side view d- front view

Table.1 Number of Fungal / Moss colonies

Isolated fungi/Moss	Number of Fungal / Moss colonies										RF %	RD %	RA %	IVI
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}				
Aspergillus niger	04	06	-	03	08	05	06	02	09	-	22.8	35.2	26.3	**84.3**
Aspergillus flavus	-	05	06	02	-	07	05	-	-	04	17.1	23.7	23.6	**64.4**
Curvularia lunata	02	01	03	01	01	02	-	01	03	01	25.7	12.2	08.1	**46.0**
Rhizopus vigricans	05	06	-	-	04	-	07	-	-	-	11.4	18.0	26.9	**56.3**
Trichoderma viride	-	-	02	01	-	01	-	-	-	-	08.5	03.2	06.5	**18.2**
Funaria hygrometrica (Moss)	03	02	-	-	02	01	-	-	-	01	14.2	07.3	08.8	**30.3**

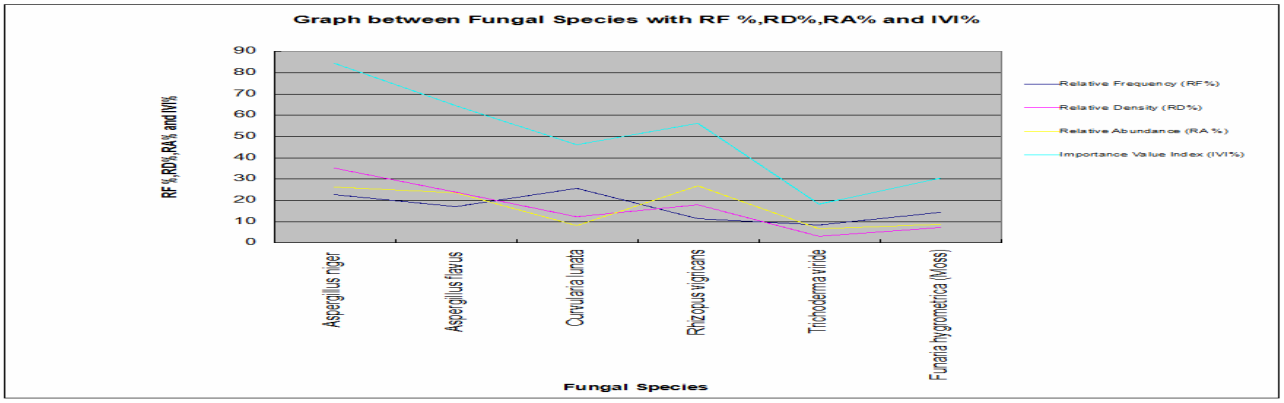

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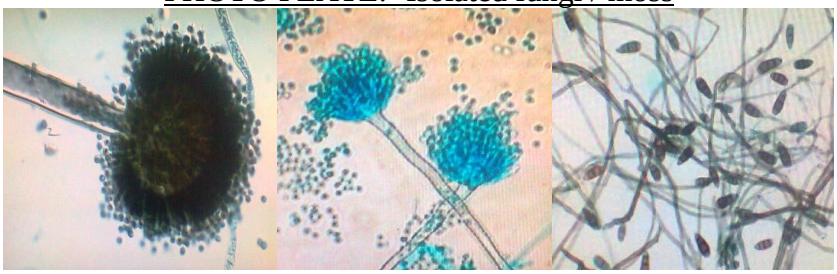
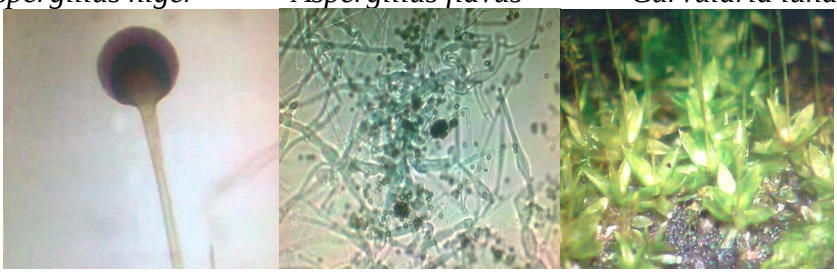
PHOTO PLATE:- Isolated fungi / moss



Aspergillus niger *Aspergillus flavus* *Curvularia lunata*



Rhizopus vigricans Trichoderma viride Fumaria hygrometrica (Moss)

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