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Investigationof Cyanobacterial Diversity and theirBio deterioration activity on the monument of Mosalae twin temple of Hassan District, Karnataka

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Abstract

Monuments contribute significantly towards preserving historical data and thereby conserving the glorious cultural heritage of a nation. Apart from these the monuments endorse aesthetic beauty, tourism and thus play an essential role in enhancing the economic status of the country. It is therefore imperative that we delve deep into it and try to make an attempt save these monuments from biodeterioration and carry forward our cultural glory. Outer surfaces of stone architectural wonders constantly being exposed to air, water and sunlight are subjected to weathering by physical, chemical and biological agents. The Photoautotrophiccyanobacteria, the primary producers in the food chain colonizeon the stone and play a vital role in the deterioration of stone monuments. They cause all-encompassing aesthetic, physical and chemical damages. The present investigation provides a concise account of diversity of epilithic Cyanobacterial population on the temple monument of Mosale twin temple in Hassan district of Karnataka, India. The samples were collected from the surface of the monument without tampering the stone material. 41 species of Cyanobacteria belonging to 18 genera of 6 families were isolated and identified, among them *Chroococcus*, *Oscillatoria*, *Lyngbya*, *Aphanocapsa* members were dominant. Copiousness of cyanobacteria on the monument wallscan likely be attributed to optimum nutrients, pH and other growth conditions.

Keywords: Biodeterioration, Cyanobacteria, Mosale twin temple, Monument, *Oscillatoria*

Introduction

Temple monuments are among the central components of historical and cultural legacy. Historic buildings and cultural heritage sites are a testimony to their creators, and also evidences of historic events and past cultures. The most beautiful and durable of stones like sandstone, limestone, granite, dolerite and other types of building materials have been used throughout history for temple construction, which today have become the cultural treasures. These natural stones are often subjected to weathering by physical, chemical and biological factors (Bhavani, et al., 2013). Biological factors like microbial colonization on the exposed surface of monuments are responsible for their biodeterioration or biological deterioration. Among the components of microbial communities, phototrophic organisms are the primary producers that play an important role in the colonization and deterioration of the stone monuments (Ciferri, 2002) While the weathering of rocks into soil is considered as an essential process for the evolution of life on Earth, biodeterioration of stone monuments is unacceptable as it causes black coloration and extensive aesthetic, physical and chemical damages due to the formation of patinas, incrustations and biofilms or crusts of variable thickness (Pattanaik and Adhikary, 2002; Saarela et al., 2004; Samad and Adhikary, 2008) resulting in the irretrievable loss of history and heritage.

Karnataka, a state of peninsular India cradles mesmerizing history and heritage. It is a home to magnificent art and architecture, holy revered temples and UNESCO world heritage sites. Mosale twin temple is one of such type of cultural heritage situated in Mosale village in Hassan district of Karnataka, India. Toady Mosale is one of the very few Hoysala temples that has remained intact in all aspects, giving us an opportunity to admire, and appreciate the Hoysala architectural grandeur. These temples together form a unique Dwikutacha, while one of the temples is dedicated to Nageshwara (Lord Shiva), the other is dedicated to Chennakeshava (Lord Vishnu) (Fig. 1). These architectural wondersare laid open to physical damage by biological components (Fig. 2). The current investigation pivots around the study of the diverse repertoire of cyanobacteria on the temple walls and their potential in deteriorating the monuments.

Materials and Methods

Collection of Samples

The entire collection work was undertaken with prior permission of the Archeological survey of India (ASI), Bangalore Circle. Samples were collected from Nageshwara and Chennakeshwara temples areas of the twin temples of Mosale in the month of March. Based on the visual appearance of algal growth a total of 8 sites at Nageshwara Temple (NT) and 6 sites at Chenakeshwara Temple (CT) were marked for sample collection, the samples were collected from the surface of the monument where the biological colonization was evident, using fine tooth brush, & non distractive adhesive tape method without causing any damage to the stone material (Fig. 3, 4). All sampled sites were found to be dry.

Fig 1: The twin temple Nageshwara & Chennakeshava temple view

Fig 2: Temple monument showing active weathering and dry algal growth

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Fig 3: Sample collection at study area

Fig 4: Sample collection using the Non-distractive adhesive tape method

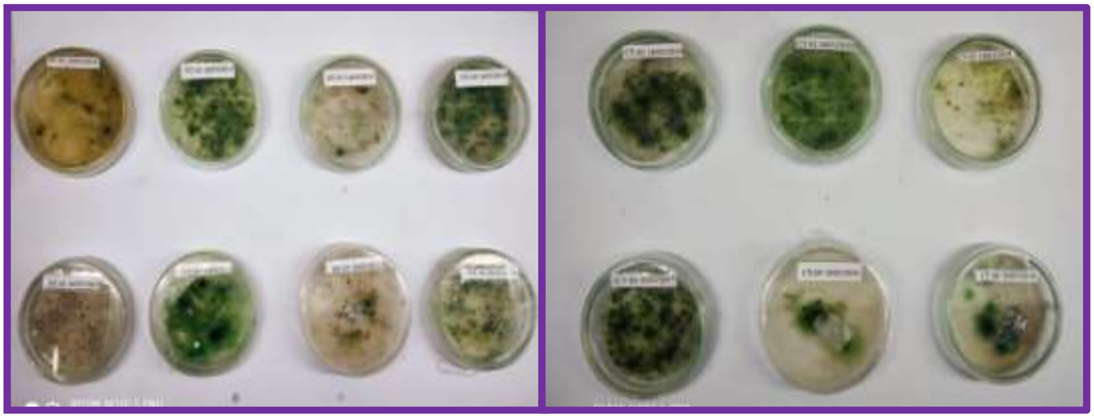

Fig 5: Nageshwara and Chennakeshava temple sample inoculated on Solid agar media

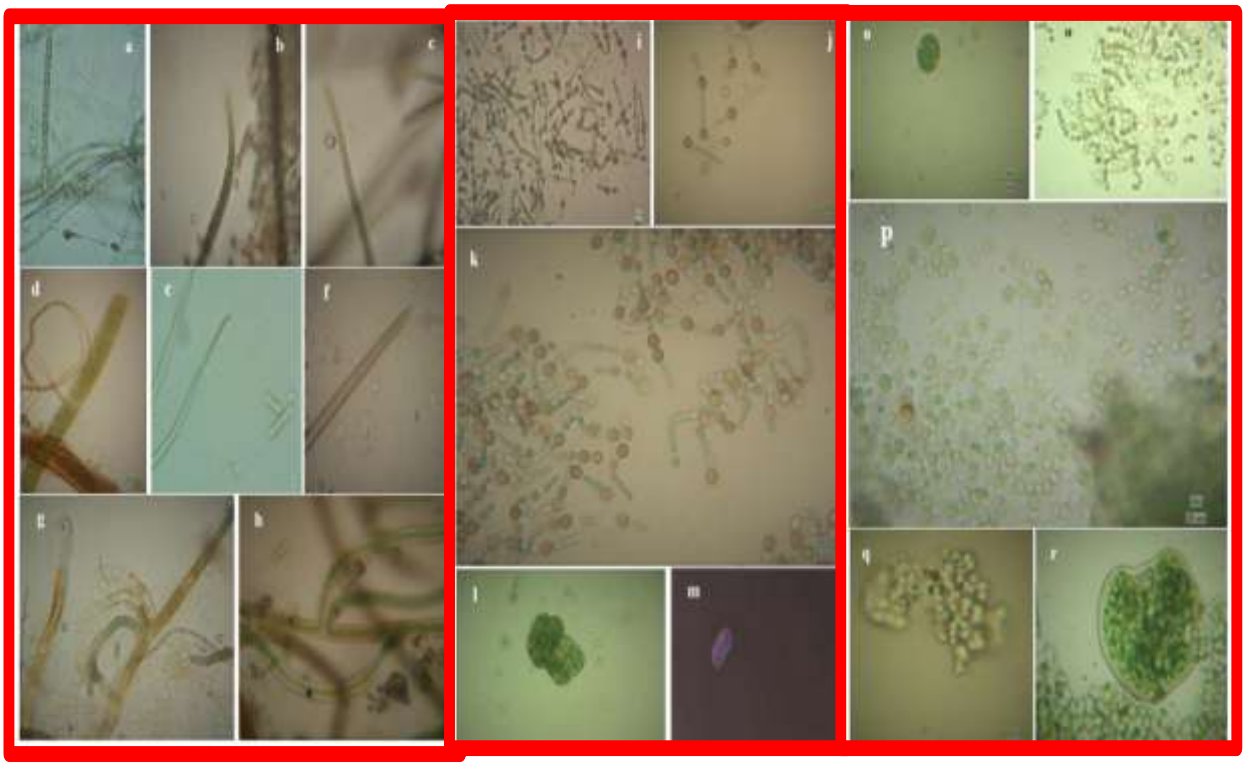

Fig 6: a- *Anabaena iyengarii* sp, b-*Oscillatoria princeps*, c- *O. fracta*, d-*Lyngbya* sp, e-*Phormidium* sp, *f-Phormidium favosum*, g-*Scytonema bohneri*, *h-Plectonema tomasinianum*, i, j, k- *Anabaena* sp, l- *Myxosarcina spectabilis*, m- *Synechococcus* sp, n-*Chroococcus* sp., o-*Nostoc commune*, p-*Chroococcus minimus*, q-*Gloeocapsa* sp., r-*Aphanotheca* sp.

Isolation of sample

Standard microbiological methods were followed for the isolation of Cyanobacteria using BG-11 media and incubated at 25 ± 2 ºC in cool white 2500 lux fluorescent tube light for 18 hours a day. The isolated Cyanobacteria were identified with help of the classical manual, Cyanophyta by Desikacharya 1959.A few of them were sub cultured in BG 11 medium
(Rippaka et al., 1979) under the above said culture conditions (Fig. 5).

Results

41 species of Cyanobacteria belonging to 18 genera (of 6 families) were isolated and identified from the biofilm on the exposed rock surfaces. The families Chroococcaceaeand Oscillatoriaceae were found to be represented by 16 species, followed by Pleurocapsaceae and Microcoleaceae with 1 species each, Nostocaceae with 5 species and Scytonemataceae with 2 species (table 1).

It was observed that the genus *Chroococcus* of family Chroococcaceae was found to be dominant with 6 species identified. This was followed by 4 species of genus *Aphanocapsa*, 3 species of *Gloeocapsa*, and a single species eachofgenera *Microcystis*, *Synecchococcus* and *Aphanothece*.

The family Pleurocapsaceae was represented by a single species of *Myxosarcina*. A total of 16 species of family Oscillatoriaceae were identified, among them the genus *Oscillatoria* predominant and represented by 9 species. This was followed by *Phormidium* and *Lyngbya* with 3 species each, and a single species of *Spirullina*.

The family Microcoleaceae was represented by a single species viz., *Microcoleus.* Family Nostocaceae was represented by 2 species of *Anabaena* and single species of *Nostoc*, *Tolypothrix* and *Calothrix*. Single species of *Plectonema* and *Scytonema* of family Scytonemataceae were observed in the samples (Fig. 6, 7).

Cyanobacterial population colonizing the temple walls were predominated by filamentous and Coccoidal forms of. Some of these organisms produced envelopes with colored sheath layer and occurred binding with finely textured epilithic surface of the monument showing algal growth.

Table 1: Cyanobacterial population on the temple monument

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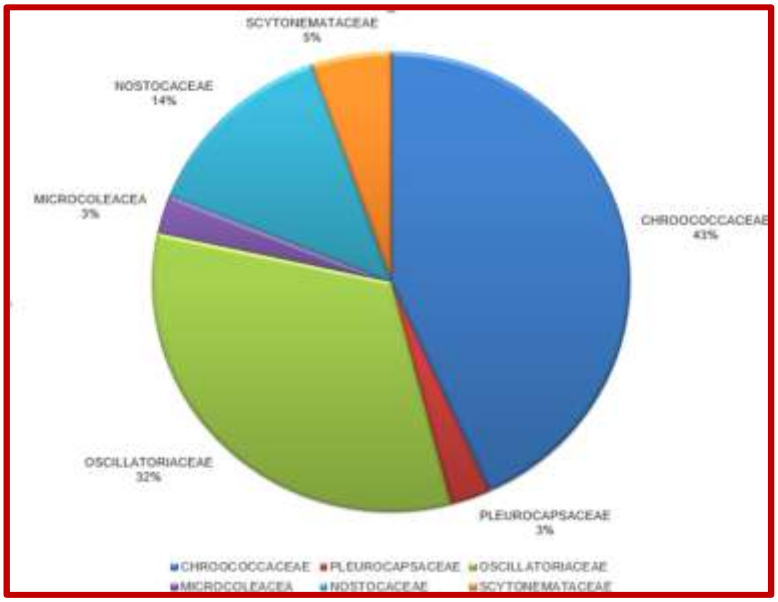
Sl. No.	Name of the Organisms	NT-01	NT-02	NT-03	NT-04	NT-05	NT-06	NT-07	NT-08	CT-01	CT-02	CT-03	CT-04	CT-05	CT-06
	CHROOCOC CACEAE														
1	*Microcystis ramosa* Bharadwaja	+	-	-	+	-	-	-	-	-	-	-	-	-	-
2	*Chroococcus macrococcus* (Kütz.)	-	-	+	-	-	+	-	-	-	+	-	+	-	-
3	*Chroococcus minor* (Kütz.) Rabenh.	-	-	+	+	+	+	-	+	+	+	-	+	_	-
4	*Chroococcus minimus* (Keissler) Lemm.	-	-	+	+	-	+	-	-	-	-	-	-	+	-
5	*Chroococcus pallidus* Näg.	+	B -	-	-	-	-	-	-	-	-	+	+	+	-
6	*Chroococcus indicus Zeller*	-	+	-	+	+	+	-	-	-	+	-	-	-	-
7	*Chroococcus* sp	-	-	+	-	-	+	-	-	+	-	-	+	-	+
8	*Gloeocapsa rupestris* (Kütz.)	-	+	-	+	-	+	-	-	-	-	+		-	-
9	*Gloeocapsa coracina* (Kütz.)	-	-	-	-	-	-	+	-	-	+		+	+	-
10	*Gloeocapsa* sp	-	+	-	+	+	+	-	-	+	-	+	+	+	+
11	*Aphanocapsa muscicola (Menegh.) Wille*	-	-	-	+	-	+	-	-	-	-	-	-	-	-
12	*Aphanocapsa* sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-
13	*Aphanocapsa koordersii Strom.*	-	-	-	+	-	+	-	-	-	-	-	-	-	-
14	*Aphanocapsa* sp	-	-	+	-	-	+	-	+	+	-	+	+	-	+
15	*Synechococcus* sp	+	-	+	+	-	-	-	-	+	-	-		-	-
16	*Aphanothece* sp	+	-	-	-	-	-	-	-	-	-	-	-	+	+
	PLEUROCAP SACEAE														
17	*Myxosarcina spectabilis* Geitler	-	-	-	-	-	+	-	-	-	-	-	-	-	+
	OSCILLATOR IACEAE														
18	*Spirulina* sp	-	+	-	+	-	-	-	-	-	-	-	-	-	
19	*Oscillatoria annae* van Goor	-	-	+	-	-	-	+	-	-	-	-	+	-	+

Fig 7: Graphical representation of the family wise distribution



Discussion

Bio deterioration of cultural heritage has become a global issue of concern. The present investigation shows that appreciable number of cyanobacteria colonize external surfaces of historic monuments. These then develop a biofilm that serves as a substrate for the growth of other microorganisms. Over a period of time it alters the appearance of the sculpture that can cause aesthetic, chemical, and physical decay of the structure. Despite being dry, the sample collection sites showed the significant amount Cyanobacteria when they were cultured under the laboratory condition; this can be attributed to their quality of being phototrophs (Vijaykumar, 2014).It indicates the presence of photo protective pigment like scytonemin, mycosporine like amino acid which protects these microorganism from the harmful UV radiation. This study is expected to have paved way for better exploration of this unanimously accepted gnawing issue. It necessitates evaluation of these photosynthetic and photo protective pigment of biofilm and further effort should be made to conserve these monuments and thereby protect our cultural glory from complete destruction.

Acknowledgements

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