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Climate-Induced Fungal Degradation And Biodiversity Impact On Heritage Monuments: A Case Study On Patna Museum In India

Suman Priya[1], Dr.Namita Kumari[2]

[1]Research scholar, Department of Botany, Patna University, Patna 800005, (Bihar) India.

[2]Professor, Department of Botany, Magadh Mahila College, Patna University, Patna 800005, (Bihar) India.

ABSTRACT

Climate change exacerbates the decay of historical monuments in India by fostering conditions conducive to fungal growth. Elevated temperatures, heightened humidity, and altered precipitation patterns promote the proliferation of fungi on these structures. Changes in biodiversity, particularly in microbial communities, further contribute to the degradation process. Effective conservation strategies must address these environmental factors to mitigate fungal damage to India's monuments. This research investigates the factors facilitating the growth of mycoflora and subsequent degradation of heritage monuments, focusing on the iconic Patna Museum, established in 1917. The museum boasts a diverse collection of artifacts, sculptures, and artworks representing Bihar's rich cultural heritage. Given its historical significance and urgent preservation needs, Patna Museum serves as a pivotal site for sample collection and analysis. This study delves into various stressors and factors, with a particular emphasis on mycoflora, that have significantly impacted Patna Museum in recent decades. The examination aims to comprehend the diversity of fungi associated with deteriorated monument sites, specifically collecting 10 samples from different locations within Patna Museum, Patna, Bihar State. Five fungal species were isolated, with *Aspergillus sp*. emerging as the most prevalent, followed by *Penicillium sp.* These identified microfungi contribute to the discoloration and mechanical exfoliation of building stone material, as evidenced by mechanical hyphae penetration and the production of dark pigments and organic acids.

Keywords: climate change, monument, biodiversity, Patna Museum

INTRODUCTION

Fungi play a significant role in the deterioration of heritage buildings and monuments, posing a threat to their structural integrity and aesthetic value (Tyagi et al,2021). Humid conditions provide an ideal environment for fungal biofilm formation on historical surfaces, leading to gradual degradation through microbial metabolism (Gaylarde and Morton,1999). These structures hold immense societal, cultural, and national significance, embodying the history and distinctiveness of their respective regions. Comprising materials such as rocks, stones, plaster, paper, wood, and painting materials, historical monuments face diverse challenges from fungal contamination (Ngoma,2009). In contemporary settings, fungal infestations in buildings pose complex problems, manifesting in various adverse effects such as paint colour fading, structural damage, and unpleasant odour. This destruction not only impacts residential houses but also jeopardizes historical landmarks and art museums. The species of fungi involved in deterioration vary based on environmental conditions, including temperature, humidity, chemical composition of substrates, and water availability (Jiang et al,2022).

Fungal growth compromises the aesthetic appeal of heritage monuments, underscoring the necessity of preventive measures and treatment protocols to safeguard these cultural treasures (Tyagi et al,2021). However, limited methods exist for effectively controlling mold growth in buildings. To address this challenge, samples will be collected from diverse exhibits within the Patna Museum, encompassing sculptures, paintings, and artifacts (Guha-Thakurta,2004). These samples will undergo thorough evaluation to assess their material composition, condition, and conservation requirements. Conservation experts will utilize the findings to devise strategies aimed at preserving the invaluable collections housed within the museum. This article examines the phenomenon of fungal degradation in heritage monuments and explores potential management options to mitigate its impact (Ballard et al,2017).

Furthermore, the escalating effects of climate change, particularly warmer temperatures and increased humidity, exacerbate the proliferation of insect pests around historical properties. Future projections indicate a heightened risk of monument degradation owing to the surge in insect populations triggered by alterations in climate variability and rainfall patterns (Barzman et al,2015). Yet, research on protecting heritage sites from biological agents, particularly insect pests, remains underexplored and inadequately studied. This study endeavours to address this gap by shedding light on the diverse physical and biological stresses faced by the Patna Museum, offering insights into the management of climate-induced fungal degradation and biodiversity impact on heritage monuments in India.

Fig1: Different deteriorating sites in Patna Museum, Patna

MATERIALS AND METHODS

Collection of Samples: A total of 10 samples were collected from various locations in Patna Museum, Patna (Bihar). Samples from various exhibits, including sculptures, paintings, and artifacts were taken into labeled, sterilized polyethylene bags using a sterilized spatula and brought to the laboratory under aseptic conditions. This sample was stored at 4°C in laboratory conditions until further examination (Pawlik-Sobecka et al, 2020).

Isolation of fungi: The Isolation of microorganisms was done by culturing the samples and by direct incubation of the samples in the moist chamber. During the investigation period, sterilization of glassware was done, and Potato Dextrose Agar (PDA) media was prepared for the isolation of microorganisms. For this, 0.1 ml of sample from different dilutions (i.e., 10^{-2}, 10^{-4}, 10^{-6} and 10^{-8}) were poured into the petridish and spread with the help of a spreader, and then this petridish was kept at 25±2°C for 07 days for incubation (Alexopoulos,1978; Barnett,1978; Ellis,1976; Gilman,1995; Gupta, S.P.,2019).

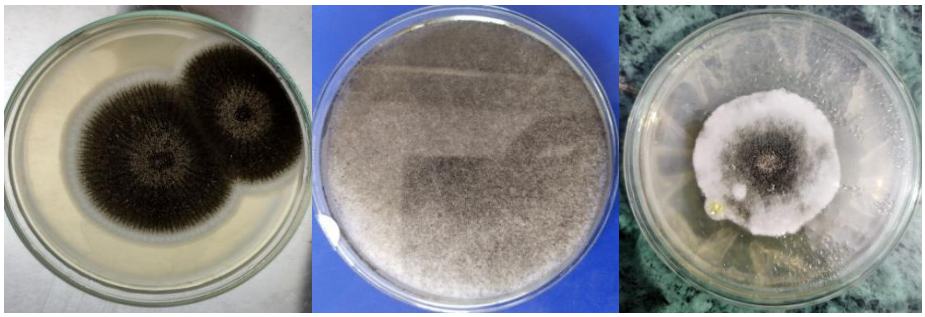
Calculations: Various myco-ecological parameters have been calculated by colony count methods (Singh ,2018).

$$Frequency(F\%) = \frac{Total\ no.\ of\ colonies\ of\ one\ species}{total\ no.\ of\ colonies\ of\ all\ species} \times 100$$

$$Density(D) = \frac{Total\ no.\ of\ colonies\ of\ a\ specific\ organism}{total\ no.\ of\ plates\ examined}$$

$$Abundance(Ab) = \frac{Total\ no.\ of\ colonies\ of\ a\ specific\ organism}{no.\ of\ plates\ in\ which\ specfic\ organism\ occured}$$

(a) **(b)** **(c)** **(d)**



(e) **(f)** **(g)**

Fig 2: (a & b) composite colony of fungal species, (c) *Aspergillus niger* (d) *Aspergillus flavus* (e) *Aspergillus eucalypticola* (f) *Rhizopus oryzae* (g) *Alternaria sp.*

RESULTS

The investigation delves into the impact of climate-induced fungal degradation on the cultural heritage housed within Patna Museum, India. Samples collected from diverse exhibits, ranging from sculptures and paintings to stones, walls, and artifacts, underwent thorough analysis to identify fungal species present. The results revealed a spectrum of fungal genera including *Aspergillus niger, Aspergillus flavus, Aspergillus eucalypticola, Rhizopus oryzae, and Alternaria sp*. **Fig 2: (c - g).**

These findings underscore the pivotal role of mycoflora in the biodegradation of the museum's monuments. The ability of these fungal species to break down organic material within the structures highlights the intricate relationship between environmental conditions and microbial activity, exacerbating the deterioration process. Such degradation poses a significant threat to the structural integrity and aesthetic value of the historical artifacts, necessitating urgent conservation efforts. Insights gleaned from this study hold promise for the development of effective conservation strategies tailored to Patna Museum's unique environmental context. By understanding the specific fungal strains involved in monument decay, targeted interventions can be devised to mitigate further damage and preserve the cultural heritage for future generations. Moreover, the data generated contribute to a broader understanding of climate-induced fungal degradation and its biodiversity impact on heritage monuments, offering valuable insights applicable to preservation practices worldwide.

DISCUSSION

Research on how fungal degradation brought on by climate change affects the cultural property kept in India's Patna Museum has provided important new information about the difficulties facing conservation efforts in the area. The study's findings highlight the complex interplay between microbial activity and environmental factors in monument deterioration (Mohapatra & Phale,2021). Among the fungal genera found in various exhibits were *Aspergillus niger, Aspergillus flavus, Aspergillus eucalypticola, Rhizopus oryzae,* and *Alternaria sp*. **Fig 2: (c - g).**

The results underscore the noteworthy contribution of mycoflora to the biodeterioration of the museum's monuments. These fungi possess the ability to decompose organic matter inside the structures, thereby presenting a substantial risk to the structural soundness and aesthetic appeal of the historical artifacts. The existence of these fungi underscores the pressing necessity of conservation measures to prevent additional harm and safeguard the cultural legacy for posterity (Singh,1999).

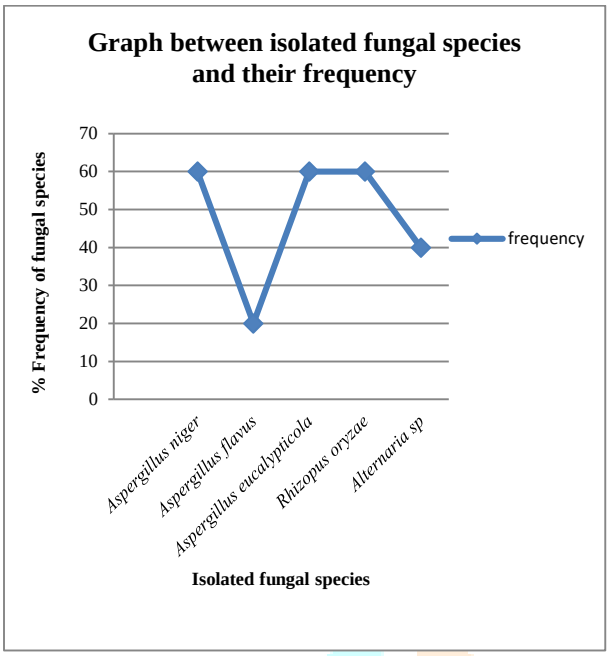
The creation of focused conservation techniques suited to the particular environmental context of Patna Museum is one of the study's main implications. Through an understanding of the particular fungal strains responsible for the destruction of monuments, conservationists might create interventions meant to stop or slow down the process. These tactics could involve targeted treatments to eliminate or stop the growth of the detected fungus species as well as environmental control techniques to manage humidity and temperature (Keulartz,1999).

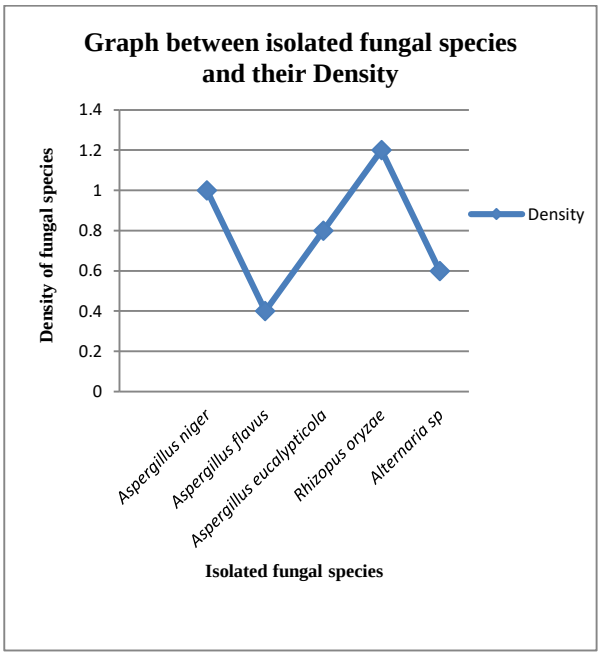
Furthermore, the knowledge gained from this study advances our comprehension of how fungal deterioration brought on by climate change affects biodiversity and heritage monuments. This work provides important insights into the mechanisms of monument deterioration, which can be applied to preservation measures not only in India but worldwide. The information produced can help researchers and conservationists around the world in their attempts to protect cultural heritage monuments from the damaging impacts of fungal degradation.

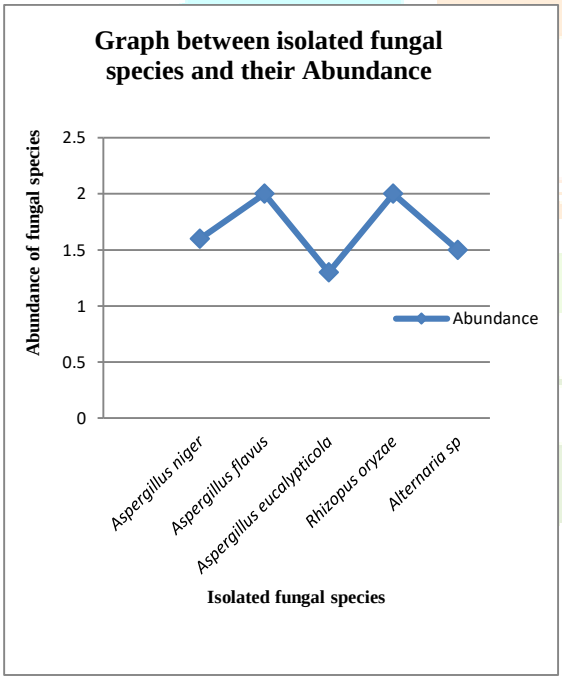
In conclusion, the findings of this study highlight the urgent necessity for proactive conservation efforts to save the cultural heritage kept in the Patna Museum and other comparable establishments across the world. Conservationists can endeavor to preserve these priceless antiques for the amusement and enlightenment of future generations by utilizing the insights obtained from this study.

Table-1 Observation

S.No	Isolated fungi	Samples					F%	D	Ab
		S1	S2	S3	S4	S5			
1	*Aspergillus niger*	-	1	2	2	-	60	1	1.6
2	*Aspergillus flavus*	-	-	2	-	-	20	0.4	2
3	*Aspergillus eucalypticola*	1	2	1	-	-	60	0.8	1.3
4	*Rhizopus oryzae*	-	-	1	3	2	60	1.2	2
5	*Alternaria sp.*	2	-	-	-	1	40	0.6	1.5







CONCLUSION

In conclusion, the investigation into the mycoflora contributing to the biodegradation of Patna's historical monuments underscores the significance of microorganisms in preserving these cultural treasures. The identified fungal species possess the capability to break down organic material within the monuments, thus playing a crucial role in their preservation. Further research into the mycoflora involved in biodegradation is imperative to comprehend their precise role in monument conservation. Notably, *Aspergillus* species emerged as the most prevalent organism at the study site. This study highlights the importance of understanding climate-induced fungal degradation and its biodiversity impact on heritage monuments, offering valuable insights for conservation efforts at Patna Museum and beyond (Bhatnagar et al, 2010).

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