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Assessment Of Indoor Mycoflora Diversity In A College Library Environment Of Sangameshwar College, Solapur

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Abstract: Indoor environments, such as libraries, are susceptible to fungal contamination, which can endanger human health and compromise the integrity of valuable materials in these environments. This study focused on identifying the presence, variety, and distribution of airborne fungi in the Sangameshwar College library located in Solapur, India, to evaluate potential health threats and recommend preventive strategies for them. Samples were gathered using the settle plate method from three key areas: the surfaces of books, bookshelves, and the librarian's desk. Fungal isolates were grown on Potato Dextrose Agar and identified through both macroscopic and microscopic examination. The investigation identified 16 fungal species across ten genera, with *Aspergillus* and *Penicillium* being the most prevalent. Bookshelves showed the greatest fungal load and diversity, likely due to dust buildup and inadequate air circulation. The detection of allergenic and pathogenic species, such as *Aspergillus fumigatus* and *Alternaria alternata*, underscores the potential health risks to library patrons and staff, including allergic reactions and respiratory issues. These results highlight the importance of regular monitoring of fungal contamination and the adoption of preventive measures, such as enhanced ventilation, humidity regulation, and cleaning, to ensure a healthy library environment. Future research should explore seasonal changes in fungal diversity to refine environmental management practices in libraries.

Key Words - Airborne fungi, fungal contamination, indoor environments, libraries, health risks, allergenic species, pathogenic species, Aspergillus, Penicillium, biodeterioration,
cellulose, lignin and Environmental management.

I. INTRODUCTION

Fungi are prevalent microorganisms that can establish themselves in a wide array of indoor and outdoor environments. The problem of indoor fungal contamination has been the subject of extensive research across various locations, such as hospitals, residential areas, industrial complexes, and roadside settings, owing to its strong connection with negative health impacts, such as allergic reactions, respiratory infections, and material degradation (Baudet et al., 2021). These fungi emit volatile organic compounds (VOCs) into the atmosphere, contributing to indoor air pollution and potentially worsening respiratory problems. Although these studies cover a wide range, there is still a significant need to improve the systems for monitoring airborne allergens.(David & Niculescu, 2021) Current monitoring initiatives tend to focus on the most common allergenic fungi, often neglecting less frequent but potentially dangerous species. To bridge this gap, monitoring technologies must advance to deliver comprehensive real-time information capable of accurately identifying a broader range of fungal spores. Such progress would facilitate prompt

public health alerts and enhance risk evaluations in at-risk groups. Improving the surveillance of airborne fungal spores is crucial for safeguarding human health and maintaining indoor environments by guiding specific mitigation efforts.

Libraries and other enclosed environments encounter specific difficulties with fungal colonization, largely because they contain organic materials, such as paper and textiles, that provide nourishment for fungi. The growth of fungi in these areas is significantly affected by environmental conditions, such as humidity, temperature, and ventilation. When relative humidity levels rise above 85%, it creates ideal conditions for fungal spores to germinate and spread on cellulose-based materials, resulting in biodeterioration that undermines both the structural integrity and aesthetic appeal of valuable collections. (Goh et al., 2000)Additionally, the ongoing manipulation of materials and poor ventilation can lead to the spread of airborne fungal spores, increasing the exposure risk for those present. This is particularly worrisome for occupational groups, such as library staff, who may experience chronic respiratory and skin health problems due to frequent contact with allergenic and opportunistic pathogenic fungi. Consequently, it is crucial to implement thorough monitoring and control strategies to reduce these risks and maintain the quality of indoor environments rich in organic materials.

Fungal growth in library settings poses a dual threat: it endangers human health and jeopardizes the preservation of cultural artifacts. Biodeterioration caused by fungi leads to the breakdown of paper fibers, resulting in discoloration and weakening of binding materials, which can cause irreversible harm to rare manuscripts, archival records, and historical books. These precious items often require specific environmental conditions for preservation, and fungal infestations disrupt these conditions, hastening the decay process.(Fouda et al., 2019) In addition, fungi engage in metabolic processes that lead to the production of enzymes such as cellulases and ligninases. These enzymes play a crucial role in decomposing cellulose and lignin, the main constituents of paper and wood, thereby accelerating the deterioration of these materials.(Ferreira et al., 2020) The financial repercussions of this degradation are significant, as repairing or replacing damaged materials requires substantial investment and specialized knowledge.

Moreover, the spores released into the air by fungal colonies can degrade indoor air quality, potentially triggering or exacerbating allergies, asthma, and other respiratory issues in both library patrons and employees. The exposure of library staff to fungal spores is a significant concern, as extended inhalation can lead to sensitization and long-term health issues. Pathogenic fungi, such as those from the *Aspergillus* and *Microsporum* genera, have been found in indoor environments and are known to cause opportunistic infections, particularly in individuals with compromised immune systems.(Lin et al., 2020) This risk is exacerbated by the enclosed spaces of libraries, where limited air circulation allows spores and volatile organic compounds (VOCs) to accumulate, thereby increasing exposure levels.

Libraries serve as enclosed spaces where books, papers, shelves, and dust create ideal conditions for fungi to thrive. Factors such as humidity and ventilation are crucial in determining the extent of fungal growth within library environments. Elevated relative humidity levels create optimal conditions for fungi to flourish on cellulose-based materials, such as books and documents, commonly found in libraries. Fungal growth can initiate swiftly when the relative humidity surpasses specific thresholds; for example, growth typically starts at approximately 85% relative humidity, and as it nears 100%, there can be a substantial increase in fungal concentrations, as evidenced by controlled environments.(Abe et al., 2021) . Fungal infestation of cellulose-based materials in libraries can cause significant harm to books and documents. Biodeterioration affects the physical, chemical, and aesthetic properties of wood. Frequent handling of books and inadequate ventilation facilitate the spread of fungal spores. Contact with these fungi can trigger health issues, such as allergic rhinitis, asthma, and dermatitis.(Maggi et al., 2000)

Moreover, fungi hasten the decay of treasured books and manuscripts. Airborne fungi play a significant role in the degradation of various library collections by serving as biodeteriogens that decompose organic materials and pose health hazards to individuals in the vicinity. Libraries and archives contain collections composed of organic substances, such as paper, textiles, and leather, which create a nutrient-rich setting for fungal proliferation when humidity and temperature are not adequately regulated. Workers in libraries and archives face health risks due to their ongoing exposure to airborne fungal spores, which can settle in the upper respiratory system and cause health issues.(Pinheiro et al., 2019) This danger is intensified by the presence of harmful fungi, including *Aspergillus* and *Microsporum.*

Fungal invasion undermines the physical and chemical stability of precious books and archival items and causes discoloration, fiber deterioration, and eventual structural collapse, posing a threat to the preservation and longevity of invaluable cultural heritage.(Pinheiro et al., 2019)

In addition to causing physical damage, airborne fungal spores present significant health hazards to those who spend time or work in these settings. Individuals working in libraries and archives are especially at risk

because of their continuous and extended exposure to these spores. Inhalation of spores can result in colonization of the upper respiratory system, potentially leading to allergic reactions, respiratory issues such as asthma and rhinitis, and skin problems. Long-term exposure may lead to sensitization and more serious health issues.(Sorenson, 1999)

The detection of pathogenic fungi, especially *Aspergillus* and *Microsporum*, significantly increases the health hazards in these settings. Aspergillus species are recognized for their ability to cause infections in individuals with compromised immune systems owing to their opportunistic pathogenicity. In contrast, *Microsporum* species are dermatophytes that cause superficial skin disease. Their presence in indoor areas, such as libraries, emphasizes the necessity of comprehensive monitoring and control strategies to ensure the well-being of occupants and the protection of collections.

A comprehensive strategy is essential for effectively managing fungal contamination in libraries and archives. This strategy should encompass the monitoring of environmental factors, control of humidity and temperature levels, improvement of ventilation systems, and establishment of consistent cleaning practices.(Ceresini et al., 2024) Furthermore, staff training and awareness initiatives are vital for the swift identification and handling of fungal outbreaks, which, in turn, reduce health hazards and safeguard invaluable cultural treasures.

This study evaluated the presence, variety, and spread of fungi within the library sections of Sangameshwar College, Solapur, with a particular focus on the implications for public health and strategies for prevention.

Air sampling methods were used in different sections of the library to collect and identify fungal spores present in the air. The collected samples were analyzed using standard mycological techniques to determine the composition and concentration of fungal species.

This study evaluated the presence, variety, and distribution of airborne fungi in the Sangameshwar College library in Solapur, given concerns about the effects of indoor fungal contamination on health and materials. This study aimed to identify the predominant allergenic fungal genera that harm health and deteriorate cellulose materials and to understand their correlation with library conditions. The findings will help improve risk assessments, guide preventive measures, and develop air quality management strategies to protect the library staff and collections.

2. Materials and Methods

2.1 Study Area

This study was conducted at the Central Library of Sangameshwar College, Solapur, Maharashtra, India. The library is a closed indoor environment with continuous human occupancy and contains a large number of books stored on wooden and metal shelves. This study was conducted to assess fungal contamination in commonly used and dust-prone areas of the library.

2.2 Selection of Sampling Sites

Three representative sites within the library were selected for fungal sampling based on the frequency of use and the likelihood of fungal growth:

- Book surfaces – outer surfaces of frequently handled books
- Book shelves – inner and outer surfaces of shelves storing books
- Librarian table – working surface used by library staff

These sites were selected to compare the fungal distribution across different functional zones of the library.

2.3 Sample Collection

Fungal samples were collected using passive air exposure (settle plate) technique.

2.3.1 Air Sampling (Settle Plate Method)

Sterile Potato Dextrose Agar (PDA) plates supplemented with antibiotics (to suppress bacterial growth) were exposed to the indoor air of the selected library sections for one day at a height of approximately 1 m from the ground. After exposure, the plates were covered and transported to the laboratory.

2.4 Culture Medium

Potato Dextrose Agar (PDA) was used as the culture medium for fungal isolation due to its suitability for the growth of a wide range of fungi. The medium was prepared using standard laboratory procedures and sterilized by autoclaving at 121℃ for 15 min.

2.5 Incubation

All inoculated and exposed plates were incubated at room temperature (25–28℃) for 5–7 days. The plates were observed daily for the appearance of fungal colonies.

2.6 Isolation of Fungi

Distinct fungal colonies appearing on the culture plates were subcultured onto fresh PDA plates to obtain pure cultures. Repeated subculturing was performed until contamination-free isolates were obtained.

2.7 Identification of Fungal Isolates

Fungal isolates were identified based on macroscopic and microscopic characteristics.

2.7.1 Macroscopic Examination

Colony characteristics such as:

1. Color
2. Texture
3. Growth pattern
4. Margin and pigmentation were recorded.

2.7.2 Microscopic Examination

Microscopic identification was performed using lactophenol cotton blue staining (LCB). Structures such as hyphae, conidiophores, spores, and sporangia were observed using a compound microscope.

Identification was performed using standard mycological manuals and identification keys.

2.8 Data Recording and Analysis

The presence or absence of each fungal species in the library sections was recorded using (+/−) notations. The spatial distribution of species and genera was analyzed and tabulated to identify contamination patterns. Morphological features such as hyphae, conidiophores, spores, and sporangia were examined microscopically, and species identification was performed using standard mycological manuals and identification keys.

3. Results

3.1 Diversity of Fungi in the Library

The investigation revealed the presence of 16 fungal species belonging to ten genera from different sections of the library.

3.2 Distribution of Fungal Species in Different Library Sections

Fungal Species	Book Shelves	Book Surface	Circulation Desk
Alternaria alternate	+	+	-
Aspergillus flavus	+	+	+
Aspergillus fumigatus	-	+	+
Aspergillus sydowii	+	+	-
Aspergillus versicolor	-	+	-
Cladosporium herbarum	+	+	-
Curvularia lunata	-	+	+
Curvularia pallescens	+	+	+
Drechslera halodes	-	+	-
Drechslera rostrata	+	-	-
Fusarium oxysporum	+	+	-
Mucor racemosus	+	+	+

Penicillium citrinum	-	+	+
Penicillium funiculosum	+	+	-
Rhizopus nigricans	+	+	+
Trichoderma harzianum	-	+	+

Table 1: Distribution of Fungal Species in Library Sections (+ Present, – Absent)

Macroscopic Fungal Identification

Fig. *Alternaria alternate*

Fig. *Aspergillus spp.*

Fig. *Cladosporium herbarum*

Fig. *Curvularia spp.*

Fig. *Drechslera halode*

Fig. *Fusarium oxysporum*

Fig. *Mucor racemosus*

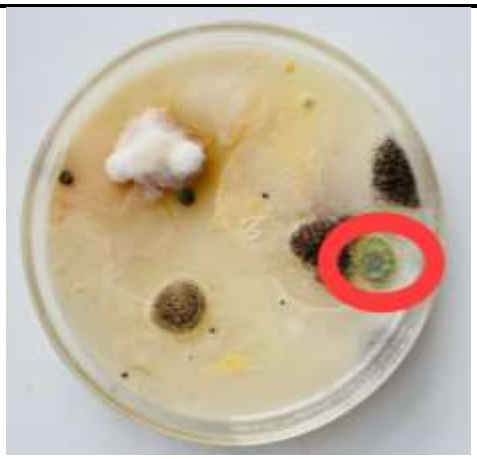


Fig. *Penicillium* spp.

Fig. *Rhizopus nigricans*

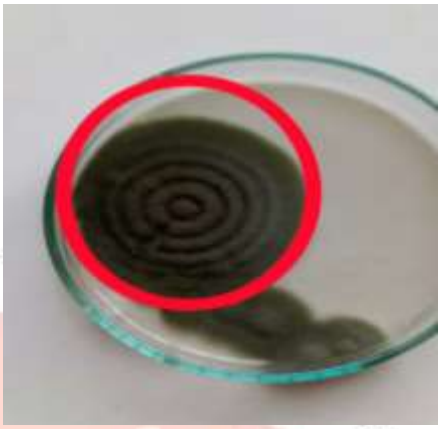
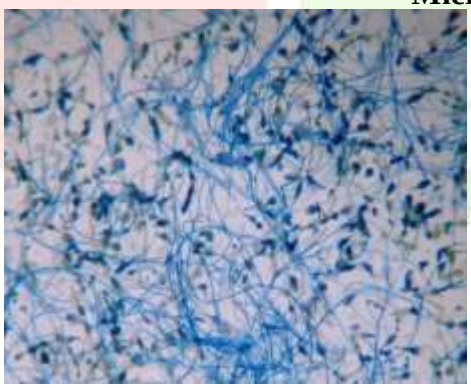


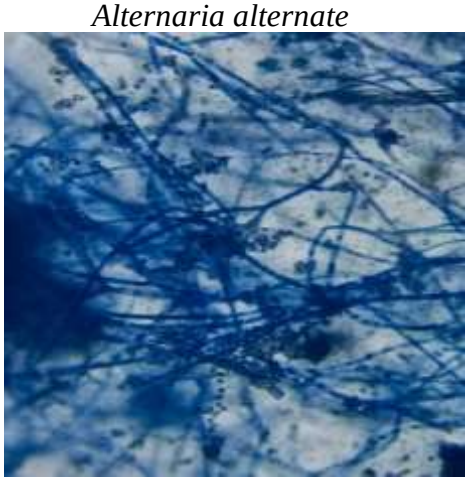
Fig. *Trichoderma viride*

Microscopic fungal identification

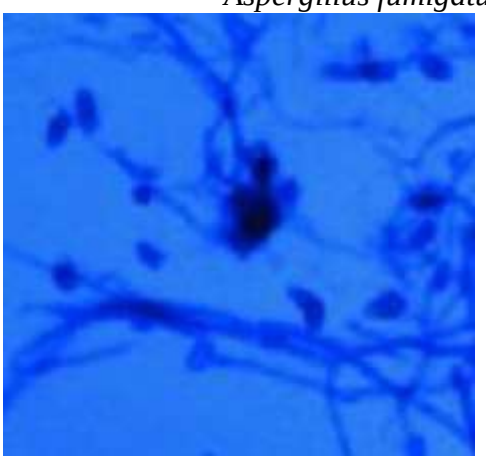


Alternaria alternate

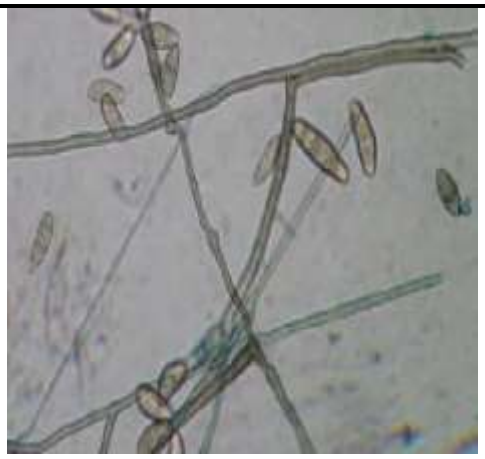
Aspergillus fumigatus



Cladosporium herbarum

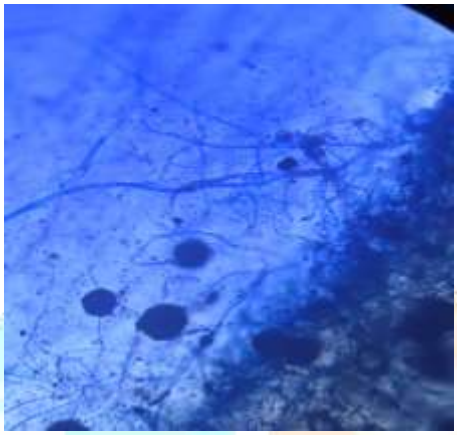


Curvularia lunata



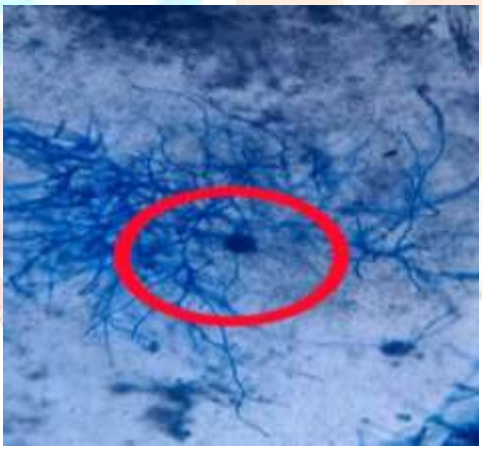
Drechslera halodes

Fusarium oxysporum

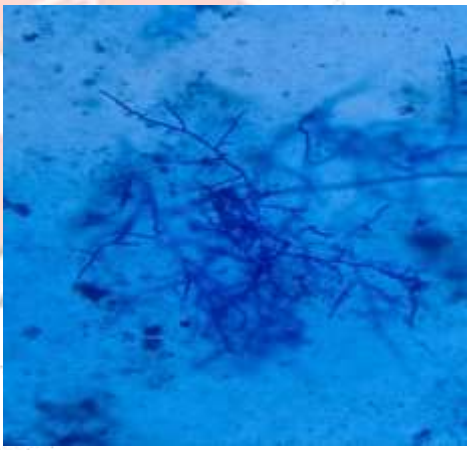


Mucor racemosus

Penicillium citrinum



Rhizopus nigricans



Trichoderma harzianum

3.3 Space-wise Distribution of Species and Genera

Table 2: Space-wise Distribution of Fungi

Library Space	Number of Species	Number of Genera
Book Shelves	10	9
Book Surface	15	10
Librarian Table	8	6

3.4 Dominant Genera

The most dominant genera recorded were *Aspergillus* (four species) and *Penicillium* (two species), followed by *Curvularia* and *Drechslera*. Bookshelves showed the highest fungal load and diversity.

4. Discussion

The findings of this study demonstrate that the library environment at Sangameshwar College in Solapur fosters a wide variety of fungal species. The high level of fungal diversity on the surfaces of books can be linked to the accumulation of dust, inadequate air circulation, and the presence of organic materials, such as paper and wood.

Aspergillus and *Penicillium* species dominate library environments because of their adaptability and prolific spore production. Poor ventilation and high humidity create conditions favorable for allergenic fungi, such as *Aspergillus fumigatus* and *Alternaria alternata*, posing health risks. Remediation should focus on improving air circulation, controlling humidity using dehumidifiers, and implementing cleaning protocols. Monitoring seasonal fungal variations can help optimize environmental management to create healthier libraries.

Morphological and microscopic analyses identified allergenic and pathogenic fungal species that pose health risks to humans. These findings indicate the need for remediation through improved ventilation, humidity control, and cleaning protocols. Future research should examine seasonal changes in fungal diversity to enhance environmental management in libraries.

Conflict of Interest Statement

The author declares that there is no conflict of interest regarding the publication of this research. The study was conducted independently without any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

All data generated or analyzed during this study are included in this published article. Additional information related to fungal isolates and observations can be made available from the corresponding author upon reasonable request.

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5. Conclusion

The study revealed significant fungal diversity in the Sangameshwar College library, Solapur, with bookshelves being the most contaminated area owing to dust accumulation and poor air circulation. The presence of medically important fungi poses health risks to both users and staff, including allergic reactions and respiratory issues. These findings highlight the need for regular monitoring of fungal contamination and the implementation of preventive measures, such as improved ventilation, cleaning protocols, and humidity control, to maintain a healthy library environment.

6. Recommendations

1. Regular and comprehensive assessments of fungal contamination across the library should be performed, concentrating on areas with a higher risk, such as bookshelves.
2. Ventilation systems should be improved to enhance air movement and eliminate stagnant zones that encourage fungal proliferation.
3. Indoor humidity should be maintained below 60% by employing dehumidifiers or modifying HVAC settings to prevent moisture accumulation.
4. Implement consistent cleaning routines that focus on dust elimination and surface disinfection, particularly in areas susceptible to dust buildup.
5. Provide focused training for library staff to strengthen their skills in recognizing and managing fungal contamination risks and implementing environmental controls.

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