A Study of Fungal Bioaerosols in Library Environment

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Abstract

Fungi are specialized micro-organisms which differ from the plant kingdom by the lack of chlorophyll and consequently cannot utilize energy directly from sunlight. The bio-deteriorative role of fungi is due to its hydrolytic enzyme activity. The cellulytic activities cause maximum damage to paper as well as binding materials of the books like leather and glue. Fungal spores in the library not only deteriorate and degrade the quality of paper but also cause allergies and allied respiratory diseases to the reader.

The study of bioaerosol has been carried out in the main library of the College. The emphasis has been given to study the fungal biodiversity and the effect of environmental conditions on the concentrations of fungal bioaerosols in the library environment. During the period of investigation, the fungi like *Aspergillus niger, A. flavus, A. fumigatus, Penicillium chrysogenum, Penicillium sp., Chaetomium globosum, Torula spp, Curvularia lunata, C. tetramera, Cladosporium herbarum, Alternaria alternata, Fusarium spp., Rhizopus, Mucor spp* were found.

Among the fungal species *Aspergillus niger, A. flavus, A. fumigatus, Penicillium chrysogenum, Cladosporium herbarium, Chaetomium globosum* were the most dominant species. Fungi like *Aspergillus niger, Chaetomium, Penicillium, Rhizopus and Alternaria* were isolated from the books, leather and binding materials in the library.

KEY WORDS: Biodeterioration, fungi, Cellulytic, Bioaerosols, Library, Fungal, Biodiversity

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INTRODUCTION

The deterioration of library material by microorganisms has attracted attention in recent years. The role of biological agents and the deterioration with reference to libraries and museums has been reviewed by many scientists. Several fungi, bacteria and actinomycetes were the microorganisms referred to as bio-deteriorating agents in the libraries and museums. (Greathouse et al. 1954; St. George et al, 1954; Kowalik, 1984). Fungi in libraries, museums and their storage rooms can seriously threaten the health of the restorers, of the museum personnel and of the visitors due to their allergic potential, due to the production of mycotoxins but also due to their ability to cause systemic infections in humans (Crook and Burton, 2010).

Books and documents are composite objects made mainly of organic compounds. Paper is based on cellulose which in natural environments represents the major source of energy for microorganisms (Florian, 2002), and parchment is made of collagen which is rich of nitrogen and therefore easily degradable by microorganisms, like filamentous bacteria and proteolytic fungi. The storage of books and documents inside structures destined to their preservation has created new, manmade environments for fungal and microbial species to inhabit (Kowalik, 1980; Zyska, 1997; Nittérus, 2000 [a &b]).

Fungal degradation of library materials causes different kinds of damage depending on the species of organism responsible for the attack and the characteristics of the substratum. Damage can occur because of mechanical stress, production of staining compounds or enzymatic action (Sterflinger, 2010; Pinzari et al., 2010). Most of the filamentous fungi associated with paper damage can dissolve cellulose fibres with the action of cellulolytic enzymes, or discolour and dissolve glues and inks. Although there is some evidence about cases of contamination of paper during the paper or bookmaking process (Florian, 2002), most of the fungal species that attack library materials come from dust and dust inhabitants. Despite this overall vulnerability, a variety of factors affect the actual growth of mold within the library collection. Certain papers, leathers, book cloths and adhesives are more susceptible to mold growth than others.

The present investigation gives the status of fungal bioaerosols that may have public health applications, since the calculation of atmospheric fungal content and the identification of certain human pathogens can show whether an atmosphere is healthy or not.

MATERIAL & METHODS

Survey of fungal bioaerosols was carried out in the college library at five different locations. The sampling was done by settle gravity culture plate method. Two different media i.e. Saboraud's agar and Potato dextrose agar were used. The 9 mm Petri plates, containing the media were exposed for 5 minute at five different locations in the library at an interval of 15 days.

The bioaerosol samples were collected before, during and after regular activities like cleaning, arranging books, loading & unloading of books with slight agitation in the book shelves. After the exposure to air, the Petri dishes were brought to the laboratory in the pre-sterilized polythene bags and incubated at 25^{o}C for 5-7 days. Colonies were counted and identified. The identification of colonies was based on their color, size, shape and other morphological features (Gilman, 1957; Barnett, 1960; Raper and Fenell, 1965; Raper and Thom, 1968; Smith, 1969; Ainsworth et al., 1972; Ellis, 1971).

The bioaerosol samples were collected from corridor i.e. outdoor sample as a control sample. The surface samples were also collected from damaged papers, binding leathers, and dust. Temperature and relative humidity of the air during the experiments were recorded.

RESULTS & DISCUSSION

The isolated colonies showed presence of 25 fungal species belonging to 15 genera with many unidentified colonies. The percentage concentration of fungal colonies of Deuteromycotina was more than Zygomycotina and Ascomycotina. Every sample, from different locations of the library showed the dominance of spores of *Aspergillus*. Many cellulose degrading fungi like *Alternaria, Cladosporium, Chaetomium, Rhizopus, Mucor, Torula, Epicoccum* etc. were recovered from the library environment. The total number of colony forming units in all of the samples taken in the library was higher than that of controlled samples. However, despite this apparent predominance of fungi inside the library, when Students' T-test was applied, no general significant differences ($p>0.05$) were seen.

The four most abundant genera, regardless of the sampling point, were *Aspergillus, Penicillium, Curvularia, and Fusarium. Aspergillus* is most prevalent genus and *Aspergillus niger* was the most dominant species followed by *A. fumigatus* and *A. flavus.* During the period of investigation it has been observed that many reference books and its leather covers were infested by different fungal species but the most frequent were fungi *Aspergillus niger, A, flavus, A. fumigatus, Chaetomium sp, Torula sp. and Penicillium chrysogenum.*

In relation to culture media, the most effective medium was PDA, in which maximum colonies were grown as compared to Sabouraud agar. But they are not statistically significant. The total number of colony forming units in all of the samples taken in library (1526 CFU) was higher than that of control air (1019 CFU). The results obtained throughout the year inside the library show maximum concentration of fungi during monsoon than in winter and summer. In summer the concentration of *Aspergillus* and *Penicillium* species were higher than the monsoon and the winter months.

Regarding the cellulose destroying activity and the damage of books caused by the common air borne fungi like *Aspergillus, Penicillium, Cladosporium, Alternaria, Chaetomium,* and *Trichoderma*, weather conditions like humidity and temperature play an important role. All the fungi recorded in this investigation are not known as cellulytic but certainly some of the strains of *Aspergillus* and *Penicillium* would be likely to attack cellulose or one of the numerous paper additives, size, glue etc. (Kakde, 2015).

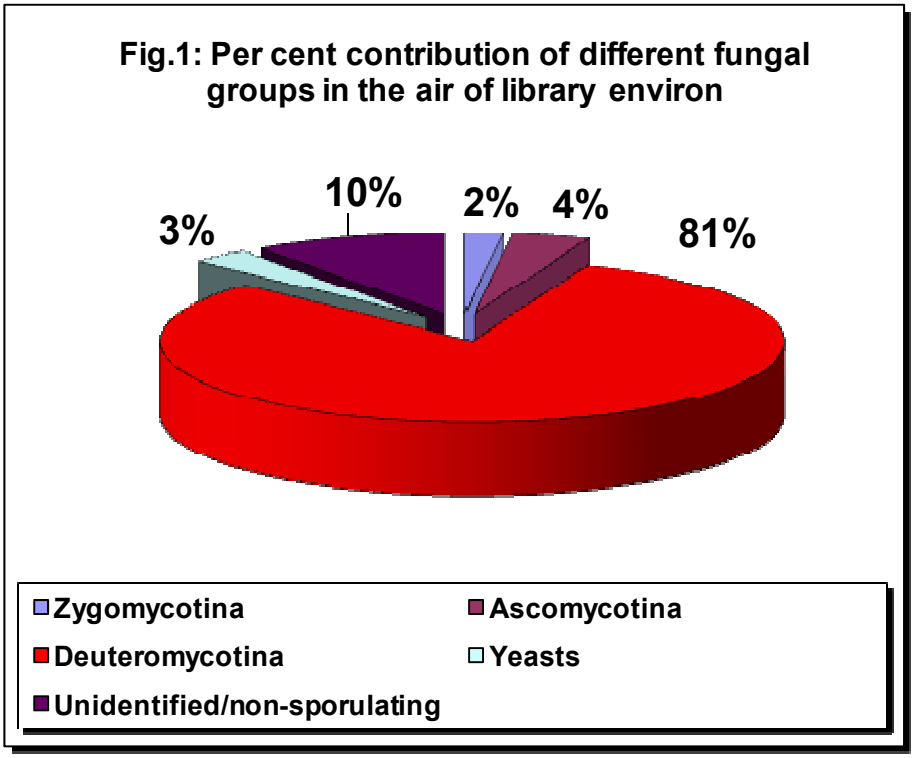
Aspergillus species were found to be dominant in this study. The predominance of *Aspergillus* species in libraries has been reported by Burge et al. (1978) who made on aerometric survey of fungi in eleven libraries at the University of Michigan to ascertain the role of fungi as allergenic contaminants in book collections with Anderson sampler. Tilak and Vishwe (1975) reported that spores of *Curvularia, Helminthosporium, Bispora, Fusarium, Torula and Cladosporium* are the common constituents in the library atmosphere of Aurangabad. Fungi such as *Chaetomium, Rhizopus, Torula, Bispora, Fusarium, Cladosporium, Curvularia* and *Trichoderma* which were reported to be common on books were observed in the present investigation. Isolation *of Aspergillus, Penicillium, Cladosporium* and *Alternaria* spp. are the most common isolated fungi in

this study was in agreement with the fungi reported by Vittal et al. (1985) and Kakde (2015) in libraries, library materials and archives.

Estimation of allergenic bio-particles in the indoor environments is of great significance. The role of fungi as causative agents of allergenic rhinitis and bronchial asthma from library dusts and other book collections is well documented by Vittal et al., (1985); Singh et al., (1995); Agrawal & Shivpuri (1974); Tilak (1982) but information on air mycoflora of libraries, especially in Mumbai is less.

CONCLUSION

It is observed that most of the fungi were encountered during the months of monsoon. In these months the relative humidity was maximum (75-90%) and temperature is relatively moderate (28-32^{o}C). The best remedy is preservation of books in well ventilated dry rooms. High concentrations of fungal spores were observed during the cleaning activity. It is recommended that for cleaning of the book shelves, floors etc. in the library, use of vacuum pump should be preferred instead of manual cleaning. Regular fumigation with fungicides is also advised for the better maintenance of books in the libraries.



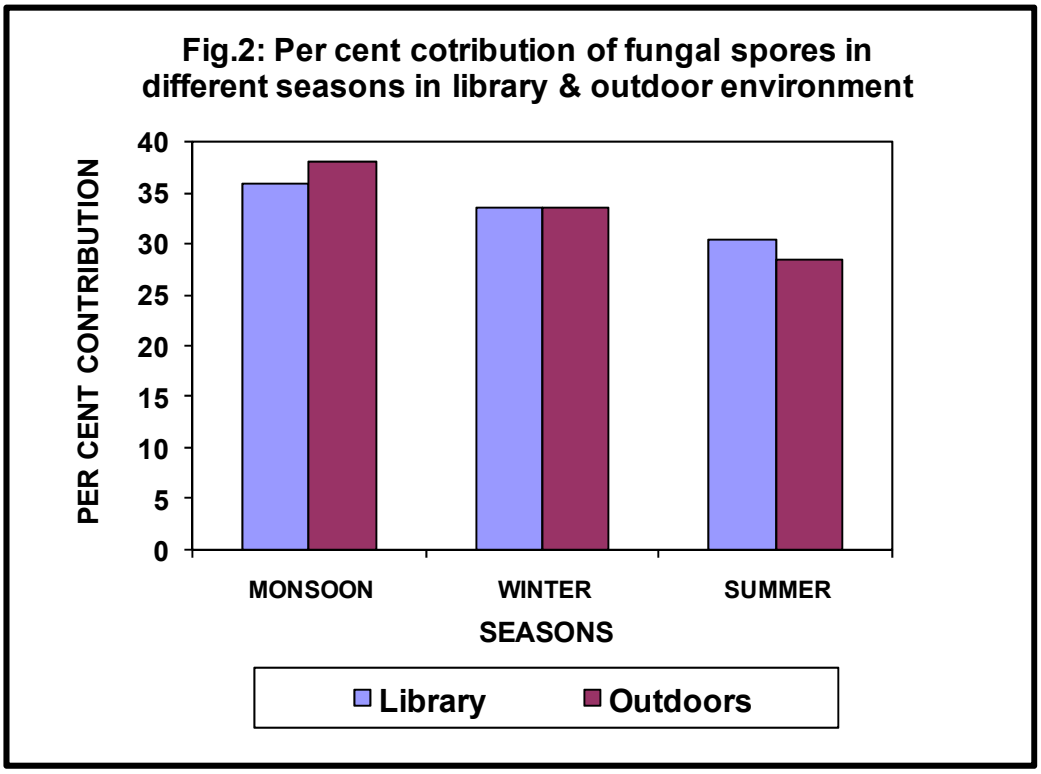


Fig.2: Per cent cotribution of fungal spores in different seasons in library & outdoor environment
PER CENT CONTRIBUTION
40
35
30
25
20
15
10
5
0
MONSOON
WINTER
SUMMER
SEASONS
Library
Outdoors

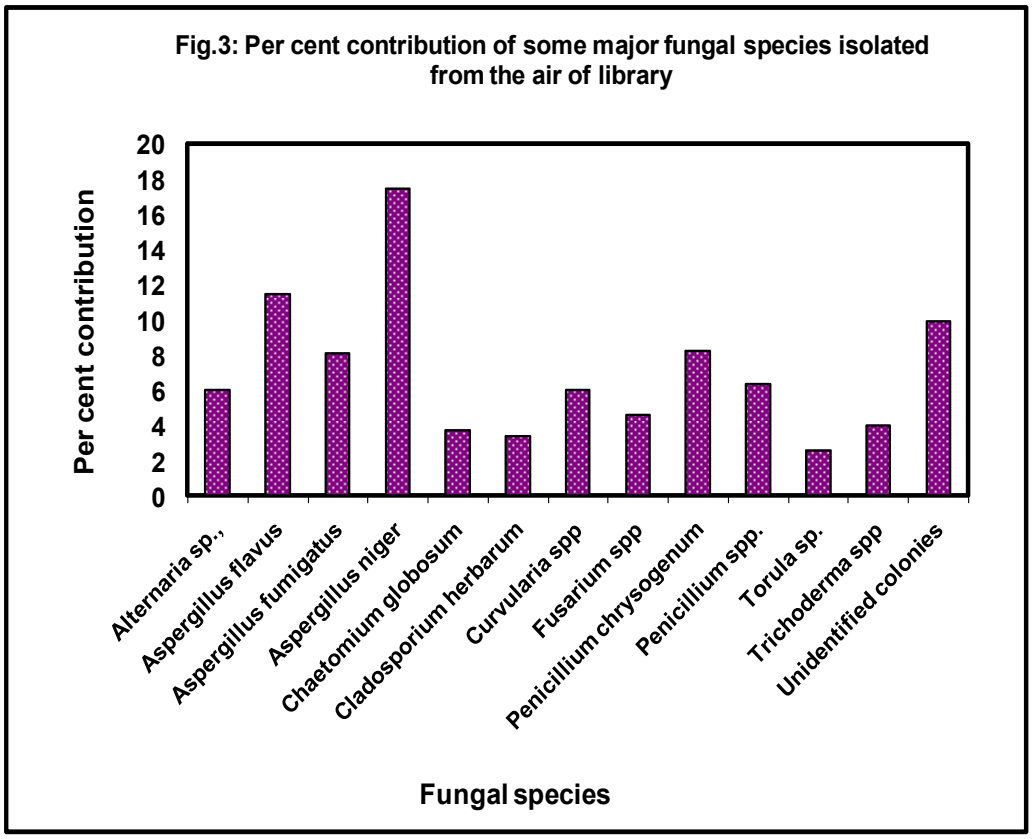


Fig.3: Per cent contribution of some major fungal species isolated from the air of library
Per cent contribution
20
18
16
14
12
10
8
6
4
2
0
Alternaria sp.,
Aspergillus flavus
Aspergillus fumigatus
Aspergillus niger
Chaetomium globosum
Cladosporium herbarum
Curvularia spp
Fusarium spp
Penicillium chrysogenum
Penicillium spp.
Torula sp.
Trichoderma spp
Unidentified colonies
Fungal species

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