Study of Indoor Air Borne pollutant: Fungi

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Abstract

Study of Indoor Air pollution at present is being taken seriously and has attracted lot of attention¹⁸. Air borne fungal contaminants pose a serious health hazard and many related problems^{8,21}. Good indoor air quality especially in schools is important to provide a safe healthy, productive and comfortable environment for students, teachers and staff. Present study was undertaken in a high school and aimed at identifying and isolating the major fungal organisms in indoor premises.

Indoor air pollution is a cause of concern for all. It is one of most significant factors affecting health and well-being of people. Indoor air is becoming an increasingly greater health hazard as people spend more time indoors. It refers to physical, chemical and biological characteristics of air in the indoor environment within an enclosed area which includes homes, offices, buildings, schools and relates to the health and comfort of the people there.

Indoor air fungi are recognised as second only to cause respiratory allergy and other related diseases in humans^{1,2,3}. Many studies related to schools have revealed that allergens are commonly found and are attached to dust particles and may contribute to allergic rhinitis and other respiratory diseases^{4,5,11}

Since children are the most vulnerable, there is a need to study the presence of moulds

and their spores in the school premises. Children spend most of their time inside the rooms of educational institutions which are common sites of air quality problems^{5,6}. Exposure to moulds for them is unavoidable and repeated exposure is an important risk factor. Any adverse interaction with fungi in the indoor environment may affect their health and comfort result in tiredness, headaches, asthma attacks and other symptoms making it difficult for students to concentrate and excel in school. In other words poor quality may ultimately affect attendance and performance²³.

The study was undertaken in the indoor environments of the Dr. Shirodkar High School. The study aimed at isolating and identifying the major fungal organisms in the school. The study can help in working out strategies for effective management and control of related troubles.

Area of study and climate :

The present study was undertaken in the outdoor & indoor environments of the Dr.Shirodkar High School (Fig. A,B & C) The Campus is spread over an area of 5815.59 square meters in the congested area of Parel having diverse type of vegetation especially trees. It is surrounded by three famous hospitals Gandhi Hospital, Global hospital, and K.E.M hospital and I.T.C Hotel. The various sites selected for recording the fungi included: Classrooms, Corridors', Assembly hall (inside & outside). In all 12sites were included for the study. (Fig. B,& Fig. C).

Climate: It is humid with minimum air temperature in summer (March – May) of 25°C and maximum 35°C and in winter (Nov – Feb) minimum mean air temperature of 15°C and maximum 25°C with annual rainfall of 2200mm &Seasons as mentioned earlier²⁹

The study was carried out for six months from November 2013 to April 2014 in the indoor and outdoor environments of Dr. Shirodkar High School Petri plates (Gravity Sampling) containing culture media Potato Dextrose Agar media (Hi media) in triplicate were exposed at monthly intervals for ten minutes at the twelve selected sites. The exposed plates were incubated at room temperature for 3 to 4 days.

The isolated fungal colonies were examined, counted, isolated and identified using cultural and morphological features and with the help of literature. The colonies were isolated, purified, sub cultured and identified and confirmed by National Fungal Culture Collection Centre of India (NFCCI) Agharkar Research institute. Pune.

During present study, a total of 14 fungal species and 8 genera were recorded (Table 1). These included *Rhizopus stolonifer*, *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus terricola*, *Aspergillus terrus*, *Aspergillus oryzae*, *Penicillium citrinum*, *Penicillium asperosporum*, *Penicillium madriti*,*Trichoderma* sp. *Chaetomium* sp. member of *Basidiomycetes*. *Alternaria* sp. and Yeast sp. (Table-1).

The most frequently occurring fungi were Rhizopus stolonifer and Aspergillus niger. These were recorded in all the months. These were followed by Aspergillus flavus. Basidiomycetes sp. And Yeast sp were less frequent than A. flavus. Aspergillus terricola, Penicillium madriti, Chaetomium sp, Alternaria sp, Trichoderma sp. and Alternaria sp. were also recorded and they were also quite frequent, but their frequency was lesser than the Rhizopus stolonifer and Aspergillus niger and A. flavus. Aspergillus terrrus, A. oryzae, Penicillium citrinum and Penicillium asperosporum, were also recorded were less frequent. (Table-1) Figures 1 & Fig. 2.

Monthly distribution during the study period revealed that the frequency of the fungi was more in the month of November, March and April. when the temperature was higher than the peak winter months *i.e*, December, January and February when it was low due to lower temperature and humidity.

It was followed by little increase in the month of March and April (Summer season). The reason for this being quite obvious *i.e.* increase in humidity and temperature, which is in accordance with earlier study.²⁹

Studies related to indoor air borne fungi in residential and schools have been carried out earlier^{10,12,19,22-26}. Fungi being ubiquitous in distribution are serious threat to public health in indoor environments.^{20,32} Inhalation or ingestion is the main way of exposure to fungi. The fungi release chemicals such as microbial volatile organic compounds (MVOC), glucans, allergens or microbial volatile breakdown substances which contribute to symptoms of illness or discomfort. Allergenic nature of hyphal fragments and spores of Rhizopus, Alternaria, Aspergillus etc has been proved by clinical investigations. These chemicals are also responsible for the musty odours produced by growing molds.^{13,40,41,43}

Fungal allergy one of the oldest ailments of human beings, is being confirmed by positive skin test. The clinical studies indicate the following allergenic spore types viz; *Rhizopus, Chaetomium*, basidiospores, *Alternaria, Aspergillus, Penicillium, Cladosporium, Curvularia* and hyphal fragments^{7,37,38.39}

Many of the species of fungi found in indoor air in this study are known to cause allergy *e.g, Alternaria,Aspergillus flavus, A niger, Penicillium citrinum.* Many of these species are also which are known to produce mycotoxins & include *Alternaria* sp. *Aspergillus flavus, A. niger, A. terreus, A. fumigates, Penicillium citrinum.*²⁸ These fungi from indoor environments in earlier studies have been frequently isolated^{9,32,36} and exposure to large amounts of fungal spores in the air has been associated with above mentioned diseases as ascertained by Epidemiologic research²².

The mere presence of these fungi in the present study can be attributed to presence of moisture and humidity congenial for growth of the moulds and fungi. There are Washrooms for girls and boys on all the floors where use of water cannot be avoided as such there are chances of getting moisture. Besides children being small visit washrooms often and splash and spill water outside also. This becomes a reason enough for presence of moisture in the premises, causes condensation on materials and supports moulds &fungi with wide range of ecological adaptations.^{35,41}

Adaptability and colonization of moulds on dead and decaying organic matter (e.g. textiles, leather, wood, paper) and even damp, inorganic material (e.g. glass, painted surfaces, bare concrete) if organic nutrients such as dust or soil particles are available is a well-known fact. Because various genera grow and reproduce at different substrate water concentrations and temperatures, moulds occur in a wide range of habitats. The most important factors include moisture, nutrients and temperature that influence their growth.³⁰

Outdoor air is the dominant source of indoor fungi, fungal spores are transported across great distances. The fungal spores enter a building through doors and windows, movement of students, people visitors and as contaminants on building materials and contents³⁴. In the present study the outdoor

air and indoor air show a close correlation. Higher concentrations of outdoor moulds and other fungi occur where trees, shrubs and landscape irrigation occur close to exterior building walls. The school is surrounded by lot of trees and vegetation.

Aspergillus niger, A flavus and species of *Penicillium* which were quite frequent in the present study have been found to be associated with damaging museum materials and manuscripts. Besides, *Aspergillus* and *Penicillium* have been found to be the most serious biodeteriorants as some of the species can survive for thirty to forty years.^{17,25}

Although the concentration of the allergic and pathogenic fungi shows close correlation yet the outdoor air has more concentration of fungi than the indoor air. It is without doubt that outdoor air is the main source of indoor air pollution, besides fungal growth is encouraged by favourable environmental factors, dampness, high temperature and presence of organic and inorganic substrates.²⁷

A total of 14 fungal species and 8 genera were recorded in the present study. These included *Rhizopus stolonifer, Aspergillus niger, Aspergillus flavus, Aspergillus terricola, Aspergillus terrus, Aspergillus oryzae, Penicillium citrinum, Penicillium asperosporum, Penicillium madriti, Trichoderma* sp. *Chaetomium* sp, *member of Basidiomycetes. Alternaria sp* and Yeast sp. (Table-1) (Figs. 1&2).

The most dominant fungi were *Rhizopus stolonifer* and *Aspergillus niger*. These were recorded in all the months followed

by Aspergillus flavus. Basidiomycetes sp. And Yeast sp were less frequent than A. flavus. Aspergillus terricola, Penicillium madriti, Chaetomium sp,Alternaria sp, Trichoderma sp. and Alternaria sp.were also recorded and they were also quite frequent, but their frequency was lesser than the Rhizopus stolonifer and Aspergillus niger and A. flavus. Aspergillus terrrus, A. oryzae, Penicillium citrinum and Penicillium asperosporum, were also recorded were less frequent.

In the present study, the kind of fungi indoors reflected those present outdoors. Besides, the study throws into prominence the fact that the role of environmental parameters particularly temperature, relative humidity and rainfall along with congested surroundings hold good.

Healthy people do not exhibit any apparent symptoms rather do not get affected, but persons with impaired defense mechanisms are susceptible to these fungi, their spores and mycotoxins⁴⁰ Studies carried out earlier suggest that poor indoor air quality can affect the health and comfort of students by causing allergy, asthma attacks, headaches, tiredness and other symptoms making it difficult for students to concentrate and excel in schools. Repeated or high exposure to airborne mycotoxins can cause mucous membrane irritation characterized by eye, nose and throat irritation.⁶² According to U.S Environmental Protection Agency Good Indoor Air Quality contributes to a favourable environment for students, performance of teachers and staff and a sense of comfort, health and well-being. These elements combine to assist a school in its core mission - educating children.

(175)

Name of the organism	MONTHS						
	November	December	January	February	March	April	%
							frequency
Rhizopus stolonifer	+	+	+	+	+	+	100%
Aspergillus niger	+	+	+	+	+	+	100%
Aspergillus flavus	_	+	+	+	+	+	83.33%
Aspergillus terricola	_	_	+	_	+	+	50%
Aspergillus terreus	_	_	_	_	+	+	33.33%
Aspergillus oryzae	_	_	_	_	+	+	33.33%
Penicillium citrinum	_	_	_	_	+	+	33.33%
Penicillium	_	_	_	_	+	+	33.33%
asperosporum							
Penicillium madriti	+	_	_	_	+	+	50%
Chaetomium sp.	+	_	_	_	+	+	50%
Trichoderma sp.	+	_	_	_	+	+	50%
Member of	_	_	+	+	+	+	66.66%
Basidiomycetes							
Alternaria sp.	+	_	_	_	+	+	50%
Yeast sp.	+	-	-	+	+	+	66.66%

Table 1. Showing fungal organisms isolated & their distribution during the study period (November2013-April2014)(5 or less than 5 colonies present were not considered.)



Figure 1 Bar Chart Showing Frequency Distribution of Organisms

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Figure 2. Pie Chart showing Frequency distribution of organisms



Dr. Shirodkar High School (Front & Side view)



Dr Shirodkar High School (Entrance) Figure A. Showing study area of Dr. Shirodkar High School



Indoor Assembly Hall



Washrooms Well ventilated Class room corridor Fig. B showing various indoor sites in the study area



Fig. C showing one of the classrooms in the study area

Corrective measures can be taken even if environmental factors and location cannot be kept in check. In winter season, many of the fungi were almost negligible and those present were less in number. Thus, first and foremost and effective measure is to reduce or eliminate the moisture content that supports mould growth. This may involve fixing leaking pipes, windows or roofs, directing rainfall or irrigation drainage away from exterior walls.

The school has good ventilation system which is quite helpful. It should be maintained and examined periodically for microbial contamination. The other effective measure is by keeping the surroundings clean especially the 'crawl' spaces and the inner & outer window ledges, by making the students discard waste material into the dustbins, by dehumidifying the classrooms especially the floors on which washrooms are. Visible mould can be removed by disinfection with chlorine bleach solution. The area being cleaned should be well ventilated, as chlorine itself is volatile and irritating. The school caters to children in two shifts, thus needs to be cleaned once more after the second shift.

A detailed and intensive study is suggested in future to assess the conditions under which these fungi may exert a health hazard ,and to determine ways to overcome such risks.

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