Indoor air mycoflora of residential dwellings in Jos metropolis

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Abstract

Background: The quality of air in the environment where one lives or works can have potential effects on human health. There are strong indications that in many parts of the world, our homes, schools and workplaces are heavily contaminated with air-borne molds and other biological contaminants.

Objectives: This study was carried out to assess the level of fungal contamination of indoor air, health related experiences of residents, and the prevalent fungi species in the homes.

Methods: The investigation was done between May 2005 and January 2006, using structured questionnaires and the agar plate exposure. 150 houses from 14 locations were examined.

Results: 380 fungi belonging to 10 species were isolated, *Chaetomium globosum* (17%), *Aspergillus fumigatus* (14%), *Stachybotrys alternans* (14%) and *Alternaria alternata* (14%) being the predominant isolates.

Conclusion: The indoor air quality of residential dwellings in Jos is poor. Rate of isolation of fungi was not significantly different in the wet and dry periods of the year and residential density affected the occurrence of fungal contaminants. Residents are displeased with fungal presence in their homes and the associated health implications. There is need for proper attention to the quality of the indoor environment.

Key words: indoor, fungi, residential, dwellings

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Introduction

Every terrestrial life requires air to thrive and the quality of the air we breathe should be of concern to all. Man requires clean air in his dwelling especially in in-door environments where a larger portion of time is spent working or resting. In modern cities and urban societies, people spend about 90% of their time indoors[1]. Unfortunately there are strong indications that in many parts of the world, our homes, schools and workplaces are heavily contaminated with air-borne molds and other biological contaminants[2,3,4].

Fungi are ubiquitous and primarily terrestrial and can thrive in extremes of environments. Their presence indoors in high concentration may portend danger for residents, as the quality of air in the environment where one lives or works can have a number of potential effects on human health. Dampness of the indoor environment encourages mold colonization and indoor air contamination.

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Molds and moisture indoor have been recognized as important health concerns. There are evidences associating indoor mold with aggravation of symptoms of asthma, headache, difficulty to concentrate[5,6] and depression[7]. Exposure to fungi indoors is particularly hazardous for persons with underlying respiratory disease, infants, the elderly, and those on immunosuppressive therapy[3].

Various aspects of fungi within a building contribute to human health problems. There is evidence that fungal spores and products of their metabolism like mycotoxins, fungal cell wall glucans, fungal volatile organic compounds and fungal cellular antigens are involved[8,9]. Common fungi in indoor environments include *Aspergillus versicolor, Eurotium* sp, *Penicillium aurantiogriseum, Penicillium chrysogenum, Cladosporium cladosporoides, Aspergillus nidulans, Alternaria alternate, Stachybotrys chartarum, Exophiala* sp, *Rhodotorula* sp and others. A number of these are a reflection of the fungi outdoors which are carried indoors through several avenues[10]. Even in buildings without apparent dampness problems fungi have been isolated[4].

Public health researchers and practitioners are increasingly aware of the adverse health effects of indoor fungi to residents and efforts should be made to enlighten the general public and government bodies on these. In most under developed and developing countries of the world, very little is done in this regard. There is sparse research and scientific reports on the levels of fungal colonization of buildings, and the potential health effects to residents. The effects of indoor mold on health are reportedly greater on the poor and low-income people who have substandard housing[1,10]. Incidentally these parts of the world present abundant factors which favour dampness of buildings and contamination of indoor air by fungi. Many urban centers are not planned, and where a plan exists, it is hardly implemented. Buildings are sited indiscriminately, without consideration for environmental hygiene or sanitation. A great number of residential settlements in the cities are, at best, slums which lack facilities for proper waste disposal, drainage systems, access roads, etc[11]. According to O'connor et al[10] higher concentrations of fungi were found in houses with dampness problem, cockroach infestation and cats. There is heavy arthropod infestation of residential buildings in the area under study and a significant percentage of these carry fungi[12]. With such environments, regular microbiological investigation of the indoor air spora and assessment of predisposing factors is a necessity.

Methods

The investigation was carried out in Jos, the capital city of Plateau State, Nigeria. Field work was done from January to May, a period covering the dry and dusty harmattan and the early rainy season of the year. A total of 150 households were sampled from fourteen locations in the metropolis. These locations were grouped into three, based on residential and population density, as low, medium and high density. Fifty houses were sampled in each group, giving a total of 150. The initial plan was to sample 20 houses from each location but this was not possible since some areas had fewer houses. The number of houses per location ranged between 11 and 20.

A questionnaire was issued to an educated resident of each of the homes visited to obtain information on variables considered in assessing the buildings for air sampling; age of the building, type of building and material used for construction, availability of utilities and services, environmental sanitation, population density and behaviour of residents, dampness of indoor environment, observed symptoms of ill health etc.

One plate each of Sabouraud's dextrose agar (SDA) and malt extract agar (MEA) was exposed in strategic spots in the rooms within the houses for 24 hours, after which they were covered, labeled and transported to the laboratory. A total of 900 agar plates were exposed in 150 households. The cultures were incubated at room temperature (26 – 30^{o}C) for one to two weeks, observed at intervals of two days for growth. Because of the variations usually observed with individual samples of air-borne fungi in buildings, the sampling was repeated two times for each location at intervals of four weeks, covering the period of rainy and dry seasons of the year. Physical counts of the fungal colonies were made, and averages of the isolation for each set of samples obtained were taken. Isolates were identified based on cultural and microscopic characteristics with the aid of standard mycological texts and manuals[13,14]. Data was analyzed using the Epi Info statistical package to test for correlation between factors assessed in the questionnaire and occurrence of fungi, also the significant difference in the frequency of isolation of fungi with respect to residential density and location of building.

Results

Questionnaire Analysis

A total of 150 questionnaires were administered, 142 of which were responded to. Table 1 shows details of the main features of the questionnaire responses. The male: female ratio of respondents was 2:3. Educational background of the respondents was averagely moderate. Most had at least secondary school education. More than 75% had complaints of respiratory symptoms, frequent headache, eye irritation and skin rash. Dampness of the indoor environment was reported in 61% of the homes, while arthropod infestation (particularly cockroaches and lesser houseflies was reported in 88.6% of the houses. 12.3% acknowledged mould growth in one or more parts of the house sometimes. More than 50% of the locations were not planned settlements and as such houses were sited haphazardly. 60% of the houses lacked proper drainages, toilet and waste disposal facilities. Refuse dumps and muddy pools were common sites. About 43% of the houses were old and some dilapidated, yet densely populated. The main features of the questionnaire as they affect fungal occurrence are as represented in Table 2.

Table 1: Features ofquestionnaire responses obtained (N = 152)

S/No	Feature	Positive responses	Percentage
1	Unplanned settlement	72	50.5
2	Males	47	33.1
3	Females	95	66.9
4	Age of building(Old)	61	43.0
5	Toilet facilities present	87	61.2
6	Waste disposal service	87	61.2
7	Dampness indoors	87	61.2
8	Mold growth indoors	17	12.3
9	Suggestive symptoms experienced	106	74.6
10	Arthropod infestation	126	88.7

Table 2: Frequency of isolation of fungi with respect to residential density

Residential Density	No. of houses sampled	Fungal isolates	% isolation
High density	50	188	49.5
Medium density	50	132	34.7
Low density	50	60	15.8
Total	150	380	100.0

Mycological investigation

The low density group was characterized by newer and stronger buildings. The lowest fungus isolation rate (16%) was obtained from this group (Table 3). Houses in the low density areas are well spaced out, and appeared to have been constructed with better quality materials such as metal doors, which would not support the growth of microorganisms. The surroundings are cleaner and less arthropod infestation is experienced.

Table 3: Occurrence of Fungi in Relation to Responses to Features of Questionnaire

Features of questionnaire	Number of positive responses	Number of fungal isolates (%)
Unplanned settlement	72	55 (14.7)
Age of building (Old)	61	43 (11.3)
Lack of toilet/drainage facility	87	24 (6.3)
Lack of waste disposal facility	87	45 (11.8)
Dampness of building	87	87 (22.9)
Mold growth in the home	17	42 (11.1)
Symptoms (respiratory, eye)	106	24 (6.3)
Arthropod infestation	126	60 (15.8)

A total average of 380 fungal isolates, made up of 10 species, was obtained. *Chaetomium globosum* (17%) was the predominant fungus isolate, followed by *Alternaria alternata* (14%), *Aspergillus fumigatus* (14%) and *Stachybotrys alternans* (14%). Details are shown in table 4.

Table 4: Mean Frequency of isolation of fungi indoors

S/No	Fungus isolate	Average Number isolated	Percentage
1	*Chaetomium globosum*	64	16.8
2	*Stachybotrys alternans*	53	13.9
3	*Aspergillus versicolor*	53	13.9
4	*Alternaria alternata*	53	13.9
5	*Aspergillus fumigatus*	37	9.7
6	*Xylohypha bantianum*	29	7.6
7	*Rhizopus sp*	28	7.4
8	*Stemphylium sp*	24	6.3
9	*Penicillium sp*	16	4.2
10	*Sepedonium sp*	13	3.4
11	*Phoma sp*	10	2.6
Total		380	100

Discussion

The rate of fungi isolation in the homes differed from reports from other parts of the world[16,19]. These fungi are among the predominantly reported isolates in indoor environments. This high prevalence may not be unrelated to the highly dusty and windy season during which sampling was done. The filthy and unplanned nature of the areas may have also contributed. Airborne fungal spores may be more readily carried from the outdoor environment into the house by the wind and human foot wears. The presence of toxin-producing fungi like *Aspergillus fumigatus, Stachybotrys alternans* and *Alternaria alternata* indoors should be a cause for concern considering the potential risk of mycotoxicosis. The risks associated with toxin producing fungi indoors have been stressed variously[8,9]. The adverse health effect, on residents, of fungal presence in indoor environments cannot be over emphasized.

The rate of isolation of fungi was not significantly varied in the wet and dry months of the year. Houses which were situated in swampy locations, however, had higher fungus isolation rates. Other researchers have indicated fungal presence in damp houses as well as in those without apparent dampness problem[4,15,16]. Of note, is the high rate of isolation of *Rhizopus* sp found only in the high density areas. It might be due to many refuse dumps in close proximity of the houses, and near absence of waste disposal facilities in these areas. This fungus is not one of the frequently reported indoor air fungi.

Higher isolation rates were obtained from the high residential density areas, probably an effect of overcrowding, poor sanitation and high arthropod infestation. This corroborates earlier suggestions[17, 18] that population density affects the quality of environment, especially as organisms may be introduced to an area as a result of increased activities and habits of residents. Also the high density group lacked most basic facilities for drainage and waste disposal, a condition which will favours proliferation of fungi.

The presence of molds indoors has been associated with a number of disease conditions[19]. Some of the species of fungi have been implicated in serious human diseases resulting from various volatile organic products of their metabolism. This further emphasizes the need for regular surveillance of the indoor air to ascertain the level of contamination, and probable risk of exposure of residents to fungi. As pointed out severally, many people are unaware of the roles fungi play in the world around them and researches on fungal diseases are not given the seriousness they deserve. This kind of investigation is especially necessary in the developing countries where interventions for indoor mold toxicity and remediation, as well as health care facilities, are still far from adequate.

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Conclusion

It is evident from this research that potentially pathogenic fungi are present in indoor environments of the study area. There is, therefore, need for sensitization of residents on the likely risks posed by these organisms both in the study area and other parts of the metropolis. Interventions by appropriate authorities will facilitate reduction of predisposing factors and hence the prevention of discomfort to susceptible residents.

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