Original Research Article

Factors Influencing Indoor Fungal Concentration, Diversity and Risk of Respiratory and Allergic Infections in Southern part of Anambra State, Nigeria

ABSTRACT

Background: Indoor environmental factors and human activities influence the presence and concentration of fungal propagules which may lead to the risk of developing respiratory infections and allergic reactions.**Aim/Objectives**: This study aimed to identify the factors that influence indoor fungal composition and determine its association with the development of respiratory and allergic reactions. **Methodology**: A total of 549 air samples and 226 nasal swabs of occupants were examined using health base questionnaire, malt extract agar and A6 single stage microbial air sampler. House dampness, mould growth on indoor materials, temperature, relative humidity, type of ventilation, type of human activity, and location of building were found to affect the prevalence and diversity of indoor fungi. **Results**: A total of 55, 46 and 50 species of fungi were isolated from homes, offices and hospitals respectively. High fungal count, were recorded in homes with moisture problems, low temperature and high relative humidity and homes located in high density areas. High cases of respiratory health problems were reported by occupants of these homes.**Conclusion**: Improvement in housing and establishment of awareness programmes can be used to lower fungal load and health problems associated with dampness in homes.It is necessary to maintain and prevent the housekeepingactivities that can predispose fungal concentration in indoor environment.

INTRODUCTION

Air Pollution by fungal spores is a matter of great concern because it has reached and advanced level that poses a potential threat to the health and well-being of the population [1; 2]. In indoor

environment fungi grows on commonly used cellulose products including paper, paper products, wood and wood products and cardboards and ceiling tiles. The indoor quality of built environment is very important because humans speed over 90% of their time indoors [3]. Reviews of epidemiological evidence have identified damp living conditions as a major risk for reporting respiratory symptoms in children and adult [4]. It has been reported that building withpoor indoor air quality is a great problem in schools due to a high number of students per classroom, insufficient outside air supply, poor construction and maintenance of school buildings [5].

The concentration of fungal spores in bioaerosols depends on three biological factors. The first is the magnitude of sporulation which is affected by temperature. The optimum temperature for sporulation is 25-30^{o}c. This is followed by release of spores from conidiophores which is affected by relative humidity and air current. The last factor is spore dimensions and weight, which affect spore adherence to a surface and its germination. The genus *Cladosporium, Penicillium and Aspergillus* produce spores in large quantity. Their spores are small and light which makes them airborne for longer period of time, therefore increasing their chances of inhalation by human and animals. The Phylloplane and moisture indicator fungi e.gAlterneriaStachybotrys respectively produce fewer, bigger and heavier spores which settles faster [6].

Humidity and Temperature affects the concentration and presence of fungi in indoor environment. Moisture control is the best method of reducing fungal growth in indoor environment [7].

This is because once water that enters buildings comes in contact with building materials it is drawn through the pores or capillaries by absorption a condition which favours the growth of fungi. The centre for diseases control notes that mould growth will develop on materials that remain wet for 48-72 hours [8].

Other factors that affect fungal growth and concentration in indoor environment includes age of building, number of occupants, nature of indoor materials (Carpet, paint wall paper, dust, Gypsum beards, woods) seasonal variations, site of building, ventilation [9], and outdoor air contamination.

METHODOLOGY

The investigation was carried out using health based questionnaires and A6 single stage microbial air sampler with malt extract agar supplemented with chloramphenicol 0.05mg/ml. Using stratified random sampling technique air samples were collected from 84 homes, 28 offices, 7 hospitals, giving a total of 549 air samples. The temperature and relative humidity of indoor environment were taken. Two hundred and twenty six (226) nasal swabs were also collected from occupants of homes, personnel in offices and care givers in hospitals sampled. The microbial air sampler is operated at an air flow rate of 28 LPM. The sampling time was 5-10minutes according to the environmental situation of the measurement condition to avoid drying of the agar surface and overloading of the plate. The sampler was set up at a height representative of the normal human breathing zone i.e 1.5m above floor level [10]. The samples were collected in the morning hours immediately after morning cleaning. The inoculated plates were sealed with masking tape to prevent contamination and incubated at room temperature for 4-14 days and observed daily for yeast and mould growth [11]. The nasal swabs were streaked on Sabouraud dextrose Agar, supplemented with chloramphenicol at 0.05mg/ml and incubated at room temperature for 2-7 days.

When growths were adequate, the mature fungal growth were examined macroscopically and microscopically. The procedure used were those employed in most mycological examinations involving a pathogenic and non-pathogenic fungi [12].

Identification of fungal isolated was based on gross colonial morphology, microscopic image observed which were matched against those contained in colour atlases of pathogenic fungi by Fery *et al.*,[13].

RESULTS

Total of 55 species of fungi were isolated from homes while 46 and 50 species of fungi were isolated from offices and hospital respectively. The predominant fungal isolates in these environments were homes, *A.niger* (82.4%), and *P.notatum*, (73.3%) offices, *A.niger* (62.9%,) *P.notatum (*47.1%) and hospitals *A.niger* (69.6%) and *P.notatum* (58.6%.). More fungal isolates were recorded in homes followed by hospitals and offices.

High fungal counts were recorded in homes with moisture problems (Fig 1). The size of the box plot showed that more fungal count were recorded in homes with damp patches than in homes with no moisture problems.

Table 1 and 2 shows the correlation analysis between temperature and relative humidity on fungal counts of the different fungal isolates. Correlation analysis indicated significant ($p < 0.05$) decrease in *C.herbanium, Phialomoniumobovatum, Phialophorareptans, Fusarium incanatum, Aspergillus alliaceus, Penicilliumgriseofulvin* counts with increase in temperature. The effect of temperature on other isolates is as shown in table 1. In Table 2 the correlation between relative humidity and fungal counts indicated significant increase in fungal counts with increase in relative humidity.

Homes located in high density area like Nnewi and Ekwulobia had higher fungal counts compared to other LGAS in Southern part of Anambra State.

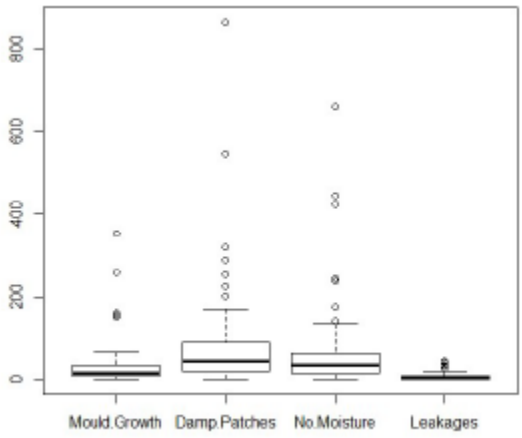

Figure 1: The box plots of mould growth, damp patches, no moisture problems and leakages in Homes, Offices and Hospitals of Anambra South during rainy seasons.

Table 1: Effect of temperature on mean total fungal counts of different types of fungal isolates.

Variables		
Temperature Vs	R	p-value
Cladosporiumherbanium	-0.234	0.004
Phialomoniumobovatum	-0.306	0.000
Phialophorareptans	-0.165	0.045
Fusarium incanatum	-0.267	0.001
Trichoderma harzianum	-0.322	0.000
Fusarium chlamydosporoides	-0.263	0.001
Aspergillus penicilloides	-0.249	0.002
Aspergillus alliaceus	-0.244	0.003
Penicilliumpiceum	-0.205	0.012
Penicilliumgriseofulvin	-0.184	0.025

Table 2: Effect of relative humidity on mean total fungal counts of different types of fungal isolates.

Variables		
Relative humidity Vs	R	p-value
A.tamarri-kita	0.202	0.014
A.terreus	0.203	0.013
Cladosporiumherbanium	0.204	0.013
Phialophorareptans	0.189	0.021
Fusarium incanatum	0.246	0.003
Fusarium subglutinans	0.310	0.000
Candida cruzei	0.195	0.018
Paecilomycesliliacinus	0.202	0.014

DISCUSSION

The dominance of *Aspergillus* and *Penicillium* species in the entire indoor environment studied is probably due to their xerophilic property and small size of their spores. These features make them airborne for longer period as a result of longer viability of their spores. This is in line with the view of Sussman and Ainsworth [14], who stated that the spores of *Aspergillus* and *Penicillium*remain viable for a longer period compared to most phylloplane fungi. Significant correlation was observed between temperature and relative humidity and fungal count of some fungal isolates. An increase in fungal count was observed with decrease in temperature and increase in relative humidity. This report is similar with the findings of Ponce-caballero *et al*., [15], who recorded higher number of species and colonies of fungi in months where relative humidity was high. Based on this study, rainy season favours greater production of spores than dry season due to higher relative humidity of the indoor environment.

Damp buildings often have mouldy smell, which are usually caused by excessive mould growth of which some are known human pathogens. More counts of fungal spores were recorded in homes, offices and hospitals that have moisture problems. Ventilation is used to control humidity; hence it can control the growth of fungi in indoor environment. Higher counts of dematiacous fungi, *Penicillium*and *Aspergillus* species were recorded in offices that use mechanical ventilation. The result of this study is similar to findings of Seppanen and Fisk [16], who reported higher prevalence of health effects in occupants of air, conditioned buildings than in naturally ventilated buildings. High cases of respiratory health problems were reported among occupants of these environments with high spore counts.

Disclaimer: - This manuscript was presented in a Conference.

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