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# Mycological Quality of Indoor Air Environment in Undergraduate Female Student Hostels, University of Benin, Benin City, Nigeria

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***ABSTRACT:*** *This study was aimed at investigating the quantitative and the qualitative analysis of the indoor air mycoflora quality of two differently designed female undergraduate student hostels (Hall 1 and Hall 5) University of Benin, Ugbowo Campus, Benin City using the gravitational settled plate methods. The plates were exposed in nine rooms each of the hostel for about 30 minutes between the hour of 8 am and 12 noon at 1.5 meters above the ground level using the Potato dextrose agar and Sabouraud dextrose agar. This study was carried out between March, 2012 and August, 2012. The mean airborne fungal counts recorded in Hall 1 ranged between 0.41 ± 0.13 x $10^3$ cfu/$m^3$ and 3.88 ± 2.24 x $10^3$ cfu/$m^3$ while the mean airborne fungal counts in Hall 5 ranged between 0.29 ± 0.07 x $10^3$ cfu/$m^3$ and 4.41 ± 2.99 x $10^3$ cfu/$m^3$. The highest airborne fungal counts were recorded in March, 2012 with the exception of Hall 1 which had its highest count in June, 2012, while the lowest counts were recorded in August, 2012. The airborne fungal isolates obtained and characterized included fifteen fungal genera. They were Mucor spp., Aspergillus niger, Rhodotorula spp., Neurospora spp., Penicillium spp., Fusarium spp., Cladosporium spp., Geotrichum spp., Microsporium spp., Stachybotry spp., Botrydiplodia spp., Chaonophora spp., Curvularia spp., Botrytis spp. and Trichoderma spp. The percentage frequency of occurrence and distribution of the airborne fungal isolates in Hall 1 revealed Mucor spp., (12.75%), Aspergillus niger (11.44%), Cladosporium spp. (10.86 %) and Geotrichum spp. (10.80%) while Hall 5 had Mucor spp., (11.88%), Cladosporium spp. (11.31%) , Aspergillus niger (11.25%) and Geotrichum sp. (7.91 %) as the most frequently recorded airborne fungal isolates. The mean measurement obtained for temperature, relative humidity and number of occupants per room sampled revealed a mean temperature range of 28°C to 29°C with a mean range of 77% to 90% relative humidity recorded throughout the research period. An average number of 7 persons per room were observed in the two halls studied. Statistical analysis of the mean airborne fungal counts revealed that there was no significant difference (P > 0.05) for the airborne fungal counts obtained from the Hall 1 and Hall 5 between March, 2012 and August, 2012. The paired T-test analysis of the mean airborne fungal counts obtained in Potato Dextrose Agar and Sabouraud Dextrose Agar showed no significant difference in Hall 5 while a significant difference was observed for Hall 1 (P > 0.05). This could be attributed to the newness of the new hostel (Hall 5) compared to the old one (Hall 1). The indoor air environment of the halls of residence examined revealed the prevalence of diverse groups of common indoor airborne mycoflora.*

**Keywords**: Female student hostel, airborne microbial isolates, temperature, relative humidity and sampling time

## Introduction

Air can be defined as the mixture of gases that makes up the earth's atmosphere. The major components of air includes: nitrogen, oxygen and carbon IV oxide. It is one of the environmental entities that allows for the interaction of organisms on earth, and like every other environment it is subject to pollution or contamination (Ayanbimpe *et al.*, 2010). The atmosphere comprises of a complex and dynamic natural gaseous system which promotes the survival of biological entities including microorganisms (Ekhaise *et al.*, 2008). Indoor air pollution and urban air quality have been listed as two of the world's worst pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report (Ayanbimpe *et al.*, 2010). Indoor air quality (IAQ) which is one of the integral parts of indoor environmental quality (IEQ), has become an important issue for the design of buildings for commercial and residential purposes since the health and wellbeing of the occupants are affected by the physical, chemical and biological properties of indoor environment (Jaffal *et al.*, 1997). Unfortunately there are strong indications that in many parts of the world, our homes, schools and workplaces are heavily contaminated with air-borne moulds and other biological contaminants (Ayanbimpe *et al.*, 2010).

Fungi are eukaryotic chemoorganotrophic microorganisms that reproduce naturally by means of spores. These spores and other airborne structures are present in the air environment and inhalation of spores are linked to a wide range of diseases from localized non-invasive pathologies to invasive and disseminated infections (Curtis *et al.*, 2005 ). These spores depending on their dimensions are classified as a bioaerosol ( Buttner *et al.*,1997).They are ubiquitous in the indoor environments and their concentration changes depending on the environmental conditions. (Kasprzyk, 2008). Consequently their estimation is important for use as an indicator for the hygienic level for any given environment and the relation they bear on human health (Jaffal *et al*., 1997). Also the knowledge of the incidence of airborne mycoflora in houses is important for their possible correlation to infectious diseases or associated allergic reactions (Fink *et al.*, 1971). Knowing the type of microorganisms and controlling them in the domestic environment may play a role in preventing many infectious diseases. Climate and human activities are the main factors that influence the composition of outdoor atmosphere. On the contrary, climate is not determinative in the mycoflora of indoor atmosphere, but human activities and the quality and maintenance of the building do play a major role in these environments. For these reasons, dominant fungi indoors vary between buildings and can be used as monitors of indoor air quality (Araujo *et al.*, 2008). The numbers and types of microorganisms contaminating the air are determined by the sources of contamination present in the environment. They include overcrowding and the nature and degree of human activities. For example microorganisms can spread through coughing and sneezing from human respiratory tract and by the circulation of dust particles by air current from the earth's surface ( Stryjakowska - Sekula *et al*., 2007).

The objectives of this study were to enumerate, characterize and identify airborne mycoflora present in indoor air and conditions of the rooms in female undergraduate hostels, University of Benin, Benin City, Nigeria.



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## Materials and Methods

### Sample location

The University of Benin, Benin City located on latitude $6^0$ 20.022N and longitude $5^0$36.009E. The institution was established in 1970 with its halls of Residence. In this study, two female undergraduate hostels namely Queen Idia Hall popularly known as Hall l and a newly built Hall 5 were used as the sampling locations.

Queen Idia hall (Hall 1) comprises of seven blocks of two storey buildings, for this study, three blocks were used as the sampling locations, each block has in it 30 sleeping room apartment. A room is designed to accommodate 6 students. These rooms are small but adequately ventilated built in 1976, thus one of the oldest undergraduate female hostel in the institution. The hall is occupied by both new and old female students. Hall 5, a relatively new hall was built in 2004 and is a storey building with 15 sleeping compartments. The hall is inhabited mainly by final year female students with each room designed to accommodate 8 students in a room. The rooms here are larger but poorly ventilated compared to the rooms in Hall 1

Figure 1 shows the map of University of Benin, Benin City with the location of the halls of residence. Plate 1 shows the front view of the Block F in Queen Idia Hall and Plate 2 shows a Block in Hall 5.

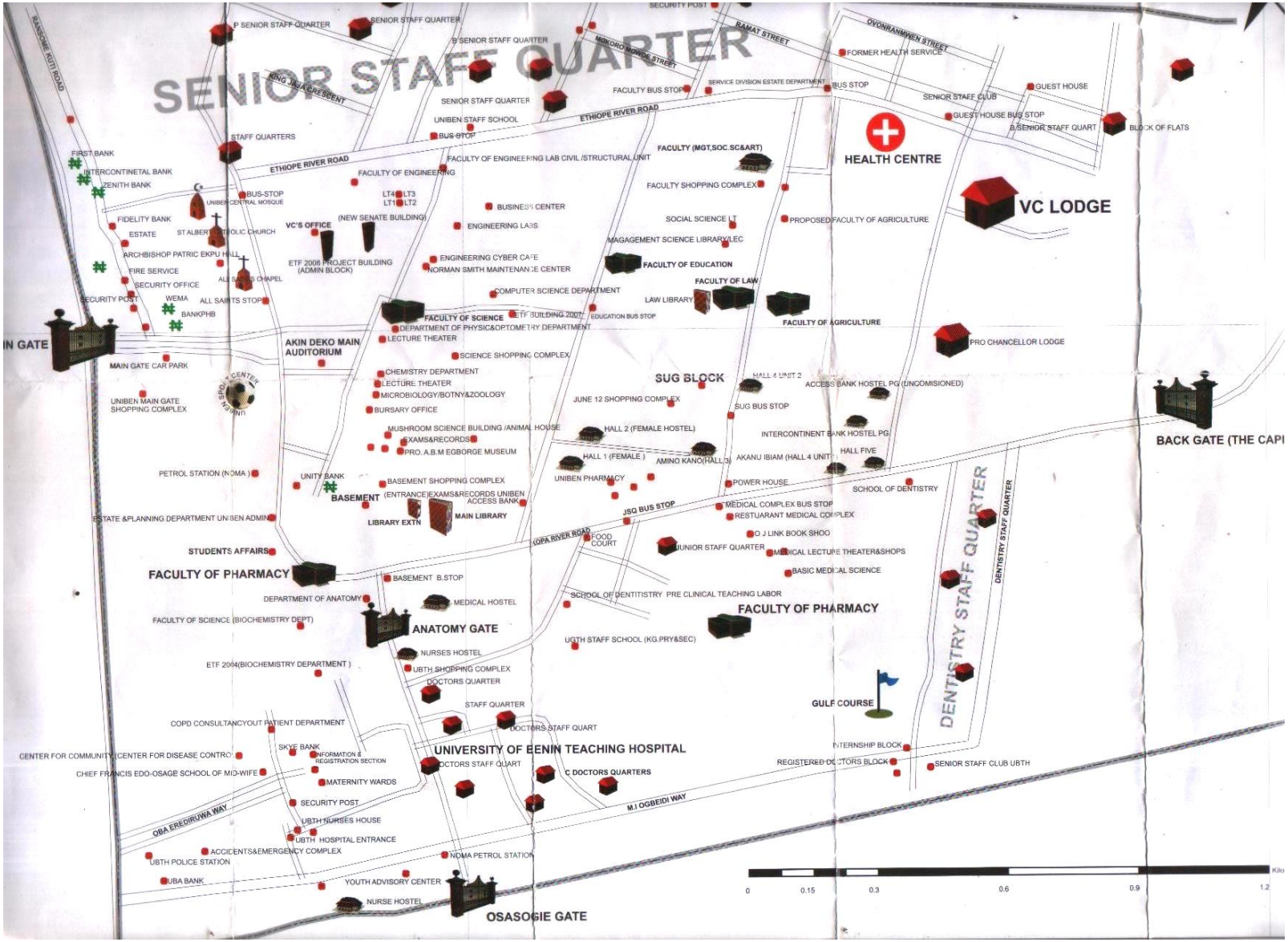


**Figure 1: Map of the University of Benin, Benin City showing the Halls of Residence**

**Plate 1: Front view of Block F in Queen Idia Hall**

**Plate 2: Inside view of Hall Five**

## Preparation of Culture Media

The culture media were prepared according to the manufacturer's instructions. Upon preparation, the media were dispensed onto sterile petri dishes. The culture medium amended with antibiotic (streptomycin and penicillin) to inhibit the growth of bacteria.

**Air Sampling**

Air samples were taken from thirteen different sites, which included nine sleeping rooms, bathroom, corridor, kitchen and common rooms for each hostel. In each of the rooms, Potato Dextrose Agar and Sabouraud Dextrose Agar (SDA) in triplicates were exposed for 30 minutes (Ekhaise *et al.*, 2008). Duplicate sampling was carried out monthly. The study was carried out between March, 2012 and August, 2012. The air samplers ( petri dishes) were set up at a height representative of the normal human breathing zone, that is, 1.5 m above floor level (Obbard and Fang, 2003). After exposure, the plates were collected and taken to the laboratory for microbiological examinations. The plates were incubated at room temperature ($25^{o}C - 28^{0}C$) for 3 - 4 days for the growth of fungal isolates. After incubation, the total number of colony forming units (cfu) of fungal isolates were enumerated and recorded as colony forming units per meter cube.

**Measurement of Indoor Environment Parameters.**

Indoor parameters like temperature and relative humidity of the sampling rooms were measured using the thermometer and hygrometer. The population of the students occupying each room was also recorded (Horner *et al*., 2008) as part of indoor environment parameters.

**Estimation of Airborne Fungi Counts**

The numbers of colonies so appeared on the exposed plates were counted. The number of microorganisms expresses as $cfu/m^3$ were estimated using Koch sedimentation method according to Latika and Ritu (2010).

$$cfu/m^3 = a.10000 / p.t.0.2$$

Where;

a - The no of colonies on the petri dishes
p -The surface area of the petri dish
t-The time of the exposure

## Fungi Identification

The colonial features of the fungal colonies were studied as well as the morphological features of the fungi using compound microscope. The determination of the morphological structures of fungi was carried out after being mounted in lactophenol and cotton blue covered with cover slip. The fungal types were analyzed for each sampling exercise. The species were identified on the basis of micro and macro morphology and surface colouration of colonies grown on the PDA and SDA media. The fungal isolates were identified according to the methods of Barnett and Hunter (1998).

### Statistical Analysis

The frequencies of isolated airborne microorganisms (fungi) in all the sampling locations were calculated. The unpaired t - test was used in analyzing the difference between the mean fungal counts obtained in all sampled locations in Hall 1 and Hall 5, while Paired t-test was used in testing the significant difference between the mean airborne fungal counts obtained in the two agar used in each of the Halls of Residence (Dutkiewicz and Augustowska, 2006).

### Results

The results obtained in the study are shown in Tables 1 – 4 and Fig. 2 below. The results presented in Tables 2 and 3 showed that the airborne fungal counts in Hall 1 ranged between $0.41 \pm 0.13 \times 10^3$cfu/m$^3$ and $3.88 \pm 2.24 \times 10^3$cfu/m$^3$. The highest airborne fungal counts recorded in Potato Dextrose Agar (PDA) plate was in June, 2012 in room 101(A) with a value of $3.88 \pm 2.24 \times 10^3$cfu/m$^3$ while bathroom had the lowest count of $0.46 \pm 0.18 \times 10^3$cfu/m$^3$ in August, 2012. The kitchen had a value of $3.61 \pm 1.37 \times 10^3$ cfu/m$^3$ in March, 2012 as the highest count in Sabouraud Dextrose Agar (SDA) plate and the lowest count was also recorded in the kitchen in August, 2012 with a value of $0.41 \pm 0.13 \times 10^3$cfu/m$^3$. Airborne fungal counts recorded in Hall 5 ranged between $0.29 \pm 0.07 \times 10^3$cfu/m$^3$ and $4.41 \pm 2.99 \times 10^3$cfu/m$^3$. In PDA plate, the highest count of $4.41 \pm 2.99 \times 10^3$cfu/m$^3$ was recorded at the corridor in March, 2012 and the lowest count of $0.31 \pm 0.02 \times 10^3$cfu/m$^3$ was recorded in the kitchen in the month of August, 2012. The highest count in SDA agar plate of $4.05 \pm 2.99$ x$10^3$cfu/m$^3$ was recorded at the corridor in March, 2012 and $0.29 \pm 0.07$ x$10^3$cfu/m$^3$ was recorded as the lowest count in room 9 in August , 2012.

Mean values obtained for temperature, relative humidity and number of occupants per room sampled (Table1) revealed a mean temperature range of $28^0$C to $29^0$C and a range of 77% to 95% relative humidity recorded throughout the research period of study. An average number of 7 persons were also observed in the rooms sampled sites in the two halls studied.

The percentage frequency of occurrence and distribution of airborne fungal isolates (Fig. 2) in Hall 1 and Hall 5 revealed *Botrydiplodia* sp. (2.57% ), *Aspergillus niger* (11.25% ), *Cladosporium* sp (10.86% ), *Aspergillus tamari* (2.48%), *Chaonophora* sp. (2.58%) , *Curvularia* sp, (7.64%), *Trichoderma* sp.(2.50%), *Mucor* sp.(12.75%), *Geotrichum* sp.(10.80%), *Penicillium* sp.(6.23%), *Aspergillus* (brown)sp. (4.58%), *Rhodotorula* sp(1.49%), *Aspergillus flavus* (4.91%), *Penicillium Italicum* (4.12%), yeast (3.20%), *Stachybotry* sp.(0.46%), Penicillium *oxalicum* (1.67%), *Fusarium* sp.(0.13%), *Botrytis* sp.(0.57%) , *Microsporium* sp.(0.05%), *Neurospora* sp.(2.21%). The airborne fungal isolates in Hall 5 includes *Botrydiplodia* sp. (1.32% ), *Aspergillus niger* (11.44% ),*Cladosporium* sp (11.31% ), *Aspergillus tamari*, (2.39 %) *Chaonophora* sp., (1.95 %) *Curvularia* sp, (7.10%) *Trichoderma* sp. (4.45%), *Mucor* sp. (11.88 %), *Geotrichum* sp.(7.91%), *Penicillium* sp. (5.56%), *Aspergillus* (brown)sp. (2.37%), *Rhodotorula* sp (0.86%), *Aspergillus flavus* (4.83%), *Penicillium Italicum* (5.47%), yeast (4.06%), *Stachybotry* sp.(0.42%), Penicillium *oxalicum* (2.00%), *Fusarium* sp.(0.18%), *Botrytis* sp.(0.47%), *Neurospora* sp. (0.52%).

The Paired T-test statistical analysis of the two media used that is Potato Dextrose Agar and Sabouraud Dextrose Agar, showed significant difference in Hall 1 and no significant difference in Hall 5 ($p < 0.05$). At $P < 0.05$, the Unpaired T-test analysis showed no significant difference between the mean summary airborne fungal counts obtained in Hall 1 and Hall 5 for the two media employed.

**Table 1: Relative humidity, temperature and number of occupants of rooms sampled (Hall 1 and Hall 5) between March, 2012 and August, 2012.**

| Rooms sampled | Hall 1 | | | Hall 5 | | | IEE permissible limits | |
|---|---|---|---|---|---|---|---|---|
| | No of occupants | T( $^o$C) | RH(%) | No of occupants | T( $^o$C) | RH (%) | Temperature $^o$C | Rel Humidity % |
| A | 6 | 29 ± 1.76 | 92 ± 0.98 | 6 | 28 ± 3.35 | 93±1.17 | 22.5 - 25.5 | < 70 |
| B | 6 | 28 ± 1.55 | 94 ± 0.83 | 8 | 28 ± 2.07 | 93±1.26 | 22.5 - 25.5 | < 70 |
| C | 6 | 28 ± 1.09 | 93 ± 1.03 | 7 | 28 ± 2.53 | 93±1.47 | 22.5 - 25.5 | < 70 |
| D | 7 | 28 ± 1.79 | 92 ± 1.63 | 8 | 29 ± 1.21 | 93±1.32 | 22.5 - 25.5 | < 70 |
| E | 7 | 28 ± 1.97 | 94 ± 1.68 | 9 | 29 ± 2.28 | 77±2.16 | 22.5 - 25.5 | < 70 |
| F | 8 | 28 ± 1.47 | 92 ± 3.21 | 9 | 28 ± 2.34 | 91±1.87 | 22.5 - 25.5 | < 70 |
| G | 7 | 28 ± 1.63 | 91 ± 1.86 | 8 | 28 ± 4.50 | 89±1.54 | 22.5 - 25.5 | < 70 |
| H | 7 | 28 ± 1.72 | 91 ± 2.92 | 10 | 28 ± 1.22 | 93±1.64 | 22.5 - 25.5 | < 70 |
| I | 7 | 29 ± 1.87 | 91 ± 1.67 | 7 | 28 ± 2.07 | 95±1.86 | 22.5 - 25.5 | < 70 |
| J | 3 | 28 ± 2.07 | 94 ± 3.39 | 1 | 28 ± 3.27 | 95±1.33 | 22.5 - 25.5 | < 70 |
| K | 2 | 28 ± 1.26 | 95 ± 2.93 | 2 | 28 ± 2.64 | 94±1.75 | 22.5 - 25.5 | < 70 |
| L | 3 | 28 ± 2.23 | 93 ± 3.16 | 2 | 28 ± 4.36 | 92±1.96 | 22.5 - 25.5 | < 70 |
| M | 18 | 28 ± 2.59 | 90 ± 5.32 | 2 | 28 ± 3.94 | 93±1.63 | 22.5 - 25.5 | < 70 |

**Key**

**T - Temperature, RH- Relative Humidity**

**A-I – Sleeping rooms, J - Bathroom, K - Kitchen, L - Common room , M - Corridor .**

**IEE – Institute of Environmental Epidemiology**

**Table 2: Air borne fungal counts (cfu /$m^3$ ± SD x $10^3$) of living rooms in Hall 1 between March, 2012 and August, 2012. (Female student hostel)**

| Media Type | March | | April | | May | | June | | July | | August | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PDA | SDA | PDA | SDA | PDA | SDA | PDA | SDA | PDA | SDA | PDA | SDA |
| **A** | 1.82±0.99 | 1.20±0.70 | 2.20±0.49 | 1.88±0.75 | 1.70±0.00 | 1.69±0.76 | 3.88±2.24 | 1.72±0.93 | 2.16±1.56 | 1.72±0.56 | 0.53±0.04 | 0.62±0.19 |
| **B** | 1.24±0.25 | 0.88±0.00 | 2.43±0.69 | 3.12±1.83 | 1.65±0.08 | 1.47±0.25 | 2.98±0.85 | 1.85±0.13 | 2.24±1.06 | 1.49±0.37 | 0.77±0.46 | 0.46±0.19 |
| **C** | 2.15±1.04 | 1.94±0.25 | 2.51±1.18 | 2.35±1.33 | 1.94±0.08 | 1.97±0.37 | 2.34±0.06 | 1.98±1.06 | 1.49±0.997 | 2.51±0.81 | 0.50±0.30 | 0.47±0.04 |
| **D** | 1.00±0.00 | 1.20±0.04 | 2.95±0.31 | 1.81±0.69 | 2.12±0.25 | 1.77±0.25 | 1.77±0.25 | 0.88±2.87 | 1.72±0.56 | 1.19±0.06 | 0.62±0.29 | 0.46±0.31 |
| **E** | 1.33±0.37 | 1.24±0.36 | 2.16±0.31 | 1.49±0.95 | 2.00±0.58 | 1.97±0.37 | 2.06±0.16 | 0.53±3.37 | 0.97±0.25 | 1.06±0.25 | 0.50±0.13 | 0.47±0.25 |
| **F** | 1.36±0.56 | 0.35±0.87 | 2.16±0.06 | 1.65±0.50 | 1.82±0.49 | 1.94±0.42 | 2.78±2.31 | 1.45±1.05 | 2.25±0.32 | 1.24±0.87 | 0.69±0.27 | 0.44±0.12 |
| **G** | 2.59±0.16 | 1.56±0.95 | 2.3±0.69 | 2.06±0.42 | 2.06±0.23 | 1.68±0.21 | 2.72±1.73 | 1.45±1.56 | 1.41±0.37 | 2.11±0.00 | 0.59±0.13 | 0.44±0.08 |
| **H** | 1.71±0.16 | 1.59±0.74 | 3.53±1.25 | 1.71±1.04 | 1.65±0.25 | 1.6±0.25 | 3.09±1.87 | 1.24±0.997 | 1.46±0.19 | 1.68±0.50 | 0.50±0.13 | 0.56±0.08 |
| **I** | 1.65±0.59 | 2.64±0.49 | 2.7±1.18 | 1.68±0.46 | 2.06±0.42 | 1.67±0.71 | 3.77±1.73 | 1.32±0.87 | 2.56±1.25 | 1.81±0.81 | 0.57±0.11 | 0.68±0.04 |
| **J** | 1.32±0.62 | 2.47±0.74 | 2.87±0.06 | 2.03±0.87 | 1.91±0.37 | 1.59±0.15 | 2.13±1.39 | 2.20±0.13 | 1.98±0.06 | 1.81±0.93 | 0.46±0.18 | 0.48±0.23 |
| **K** | 2.79±0. 45 | 3.61±0.37 | 2.73±0.25 | 1.82±0.66 | 2.15±0.21 | 2.21±0.87 | 1.99±1.08 | 1.15±1.12 | 1.76±0.38 | 2.16±0.06 | 0.72±0.1 | 0.41±0.13 |
| **L** | 1.97±0. 29 | 2.50±0.04 | 2.29±0.25 | 2.49±0.78 | 1.59±0.33 | 2.50±0.95 | 2.04±0.23 | 2.29±0.75 | 1.41±1.11 | 2.60±1.43 | 0.56±0.29 | 0.43±0.12 |
| **M** | 3.30±0. 06 | 2.49±0.21 | 1.85±0.62 | 1.29±0.08 | 2.71±0.25 | 1.56±0.29 | 2.07±0.31 | 1.76±0.75 | 2.99±0.63 | 2.07±0.06 | 0.57±0.23 | 0.48±0.19 |

**Key: A-I – Sleeping rooms, J - Bathroom, K - Kitchen, L - Common room, M - Corridor . PDA - Potato Dextrose Agar , SDA - Saboraud Dextrose Agar**

**Table 3: Airborne fungal counts (cfu /$m^3$ ± SD x $10^3$) of living rooms in Hall 5 between March, 2012 and August, 2012. (Female student hostel)**

| | March | | April | | May | | June | | July | | August | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Media Type** | **PDA** | **SDA** | **PDA** | **SDA** | **PDA** | **SDA** | **PDA** | **SDA** | **PDA** | **SDA** | **PDA** | **SDA** |
| **A** | 1.26±0.13 | 1.32±0.13 | 1.58±0.13 | 2.12±0.74 | 1.99±0.16 | 1.20±0.30 | 1.95±0.11 | 2.91±2.12 | 0.97±0.37 | 0.84±0.06 | 0.52±0.02 | 0.43±0.02 |
| **B** | 2.44±0.78 | 1.76±1.24 | 1.81±0.93 | 2.49±1.21 | 1.71±0.33 | 1.68±0.29 | 2.25±0.56 | 1.49±1.12 | 1.94±0.00 | 0.66±0.06 | 0.44±0.24 | 0.35±0.13 |
| **C** | 2.44±0.78 | 1.38±0.71 | 1.50±0.13 | 1.71±0.16 | 1.65±0.74 | 1.82±0.92 | 1.16±0.23 | 1.53±1.99 | 1.19±0.69 | 1.36±0.18 | 0.40±0.06 | 0.44±0.25 |
| **D** | 1.97±0.37 | 1.09±0.29 | 1.89±0.81 | 2.82±1.50 | 1.76±0.58 | 1.49±0.21 | 3.10±0.79 | 2.20±0.62 | 1.02±0.06 | 0.57±0.18 | 0.32±0.12 | 0.46±0.15 |
| **E** | 2.00±0.58 | 2.77±1.67 | 5.02±0.25 | 2.47±0.25 | 1.79±0.13 | 1.79±0.45 | 2.39±1.02 | 1.49±0.37 | 1.15±0.12 | 0.70±0.00 | 0.43±0.19 | 0.43±0.15 |
| **F** | 1.76±0.75 | 2.41±0.91 | 1.62±0.68 | 2.24±1.58 | 1.39±0.28 | 1.47±0.58 | 1.23±0.00 | 7.04±0.00 | 1.24±2.37 | 1.15±0.74 | 0.37±0.02 | 0.49±0.22 |
| **G** | 2.38±0.87 | 3.41±0.33 | 1.46±0.19 | 2.07±0.18 | 1.49±0.37 | 1.97±0.04 | 2.29±1.49 | 3.26±0.37 | 1.06±0.37 | 0.93±0.32 | 0.37±0.02 | 0.41±0.00 |
| **H** | 1.18±0.08 | 1.70±0.41 | 1.67±0.62 | 2.42±1.68 | 1.62±0.63 | 1.44±0.63 | 2.66±0.85 | 1.67±1.12 | 0.84±0.06 | 0.71±0.12 | 0.46±0.06 | 0.46±0.06 |
| **I** | 2.06±0.42 | 2.03±0.37 | 1.98±1.43 | 2.49±0.95 | 1.71±0.25 | 1.71±0.50 | 1.71±0.16 | 2.60±1.68 | 1.15±0.00 | 1.19±0.06 | 0.51±0.19 | 0.29±0.07 |
| **J** | 2.47±0.50 | 1.88±0.33 | 3.18±0.99 | 2.42±0.44 | 1.76±0.00 | 1.29±0.00 | 2.69±0.81 | 2.55±2.62 | 0.97±0.13 | 1.06±0.75 | 0.46±0.06 | 0.43±0.27 |
| **K** | 2.87±1.44 | 2.49±0.78 | 2.29±0.49 | 2.03±0.12 | 1.61±0.54 | 1.79±0.04 | 1.75±0.15 | 2.34±1.56 | 1.50±0.62 | 1.19±0.69 | 0.31±0.02 | 0.40±0.06 |
| **L** | 2.26±0.71 | 2.49±2.16 | 3.08±0.75 | 2.38±1.25 | 3.41±0.33 | 2.18±0.997 | 1.06±0.00 | 1.98±0.31 | 1.19±0.18 | 1.32±0.00 | 0.38±0.04 | 0.53±0.04 |
| **M** | 4.41±2.99 | 4.05±2.99 | 1.85±0.37 | 2.34±1.56 | 1.95±0.35 | 1.85±0.37 | 2.15±0.15 | 1.59±0.74 | 1.98±1.31 | 1.19±0.18 | 0.38±0.04 | 0.57±0.19 |

**Key: A-I – Sleeping rooms, J - Bathroom, K - Kitchen , L - Common room**
**M - Corridor . PDA - Potato Dextrose Agar , SDA - Saboraud Dextrose Agar**

**Table 4: Cumulative value of the airborne fungal counts (cfu /$m^3$ ± SD x $10^3$) recorded in Hall 1 and Hall 5 between March, 2012 and August, 2012**

| Sampling Sites | Hall1 | | Hall5 | |
|---|---|---|---|---|
| | PDA | SDA | PDA | SDA |
| **A** | 2.05±0.99 | 1.47±0.48 | 1.38±0.57 | 1.47±0.90 |
| **B** | 1.89±0.81 | 1.55±0.92 | 1.77±0.70 | 1.41±0.78 |
| **C** | 1.82±0.74 | 1.87±0.72 | 1.39±0.67 | 1.37±0.49 |
| **D** | 1.70±0.82 | 1.22±0.52 | 1.68±0.94 | 1.44±0.93 |
| **E** | 1.50±0.68 | 1.13±0.57 | 2.13±1.57 | 1.61±0.93 |
| **F** | 1.84±0.74 | 1.18±0.65 | 1.27±0.49 | 2.47±2.35 |
| **G** | 1.95±0.81 | 1.55±0.60 | 1.51±0.76 | 2.01±1.20 |
| **H** | 1.99±1.12 | 1.41±0.45 | 1.41±0.77 | 1.40±0.72 |
| **I** | 2.23±1.09 | 1.63±0.64 | 1.52±0.59 | 1.72±0.87 |
| **J** | 1.78±0.82 | 1.76±0.70 | 1.92±1.05 | 1.61±0.83 |
| **K** | 2.02±0.76 | 1.80±1.08 | 1.72±0.86 | 1.71±0.79 |
| **L** | 1.64±0.62 | 2.14±0.84 | 1.90±1.21 | 1.81±0.75 |
| **M** | 2.25±0.99 | 1.61±0.69 | 2.12±1.30 | 1.93±1.19 |

**Key: A-I – Sleeping rooms J - Bathroom K - Kitchen L - Common room**
**M - Corridor . PDA - Potato Dextrose Agar , SDA - Saboraud Dextrose Agar**

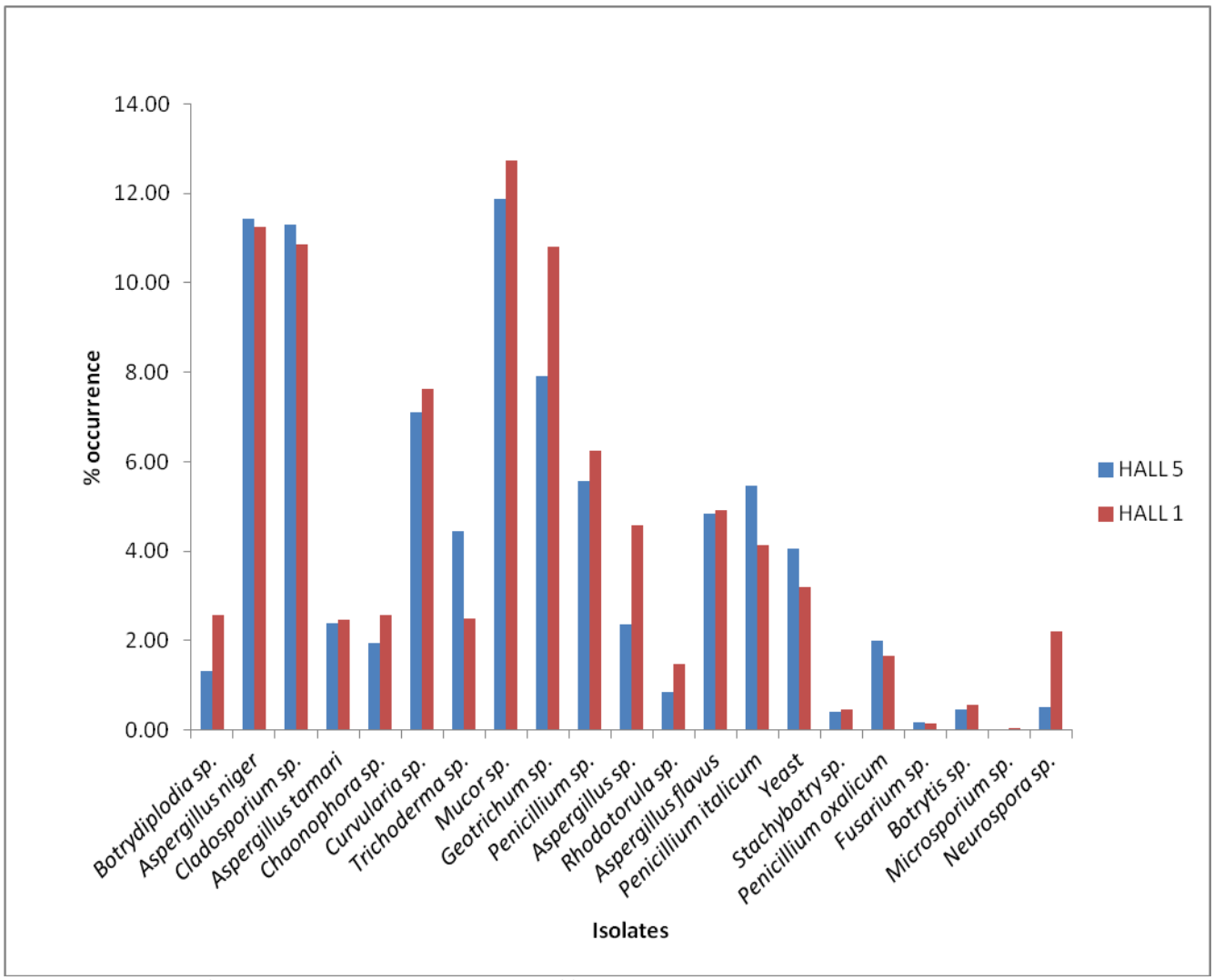


**Figure 2: Comparison of percentage occurrence and distribution of fungal isolates in Hall 1 and Hall 5**

**Discussion**

This study highlights the mycological quality of female undergraduate student's hostels in the University of Benin, Benin City. The result obtained from the mycological quality assessment between March, 2012 and August, 2012 showed variability in the airborne fungal counts between the various sampling sites in the two halls of residence studied. This result is in agreement with the report of Stryjakowska-Sekulska *et al*. ( 2007), who reported a high variability in indoor fungi counts obtained in examined University rooms. The observed variability could be a reflection of changes in indoor environmental factors such as the indoor temperature and relative humidity. Araujo and Rodrigues (2004) and Nielsen (2003) reported the influence of temperature and relative humidity on indoor fungal concentration. Other factor could be the building quality and maintenance. Building design is reported to influence indoor airborne fungi concentration and variability (Wemedo *et al.*, 2012; Araujo *et al*., 2008a). Wemedo *et al.* (2012) reported a positive correlation between the structural design of a building and indoor airborne fungi concentration. They observed that well-structured buildings with proper ventilation and less human activities had lower airborne fungal counts when compared to poorly ventilated and overcrowded buildings. High fungal counts were also recorded in well ventilated overcrowded buildings. It was also observed that, high airborne fungal population was recorded in March, 2012 compared to Augusr, 2012. This could be attributed to the changes in the microclimatic. The corridor is not an enclosed site compared to other rooms sampled, hence the high count recorded could be influenced by the outdoor air since indoor air fungal concentration is largely influenced by the outdoor airborne fungal concentration **(**Flannigan, 1997; Horner *et al*., 2004**).**

The insignificant difference in the airborne fungal counts obtained in Hall 1 and Hall 5 could be a reflection of the structural design of the two halls examined. Hall 1 was observed to have well ventilated rooms, a factor that could have contributed to a reduction in heterotrophic fungal counts. The average number of occupant per room must have contributed to the high heterotrophic airborne fungal counts. Consequently, less provision was made for effective ventilation. Yassin and Almouquatea, (2010) reported that the higher the number of residents confined to a small space, the higher the build – up of airborne microbes. This statement is in agreement with Stryjakowska-Sekulska *et al*. (2007) who reported a strong relationship between physical factors such as occupant density, human activity and microbial concentration in the indoor air environment.

The percentage frequency of occurrence and distribution of airborne fungi isolates showed a consistency in the species of isolates in both Halls of residence studied (Table 9). A total of 15 genera of fungi were isolated in this study. The high number of airborne fungi genera isolated could be attributed to the period of study which was across dry, mid-season and wet season. (Grant,1989**).** The most frequently isolated fungi in Hall 1 were *Mucor* spp., (12.75%), *Aspergillus niger* (11.44%), *Cladosporium* spp. (10.86%) and *Geotrichum* sp.(10.80%) while the least isolated fungi were *Microsporum* (0.05%), *Botrytis* spp. (0.57%), *Stachybotry* spp. (0.46%) and *Fusarium* spp.(0.13%). The fungal isolates most frequently isolated in Hall 5 were similar as those observed in Hall 1. They included *Mucor* spp., (11.88%), *Cladosporium* spp. (11.31%), *Aspergillus niger* (11.25%) and *Geotrichum* spp.(7.91%) while the least recorded species include *Botrytis* spp., (0.47%), *Stachybotry* spp.(0.42%) and *Fusarium* spp. (0.18%). The isolation of *Mucor* spp. and *Cladosporium* spp. as most the most frequently isolated airborne fungal isolates agrees with the work of Wemedo *et al.* (2012), who reported the isolation of *Mucor* spp., *Cladosporium* spp., and *Rhizopus* spp. as the most frequently isolated fungal isolates in all sites examined. In the study, it was revealed that, an average indoor relative humidity in most of the sampling sites were recorded to be > 90% except for few sampling sites which had < 90% in the two halls of residence. Grant (1989) reported that *Mucor* spp. requires high moisture content and a relative humidity > 90% for optimal growth. In this study, *Aspergillus niger* was also reported to be prevalent in all the rooms sampled as similarly reported by Ogórek, *et al.* (2011); who stated that *Aspergillus niger* was the most prevalent fungal isolates. Krzysztofik (1992) reported that high counts of *Aspergillus niger* could be attributed to the age of the building, as it been observed that old buildings provides favourable conditions for the growth of moulds. *Stachybotrys* spp. has been reported at low prevalence, being present in less than 3% of samples (Kozak *et al.*, 1985; Miller *et al.*, 1988). Danny *et al.* (1998) reported in their studies *Penicillium* spp. and *Stachybotrys* spp. are strongly related with sick building syndrome. Horner *et al.*, (2004) categories *Stachybotrys* spp. as amongst the water indicator organisms which indicate that the sampling site must have been damp or had in them dampy substrates.

The mean measurements obtained for temperature and relative humidity in the two halls showed no variations between the results obtained in the two halls studied (Table 1) . The mean values ranges of $28^0$C to 29 $^0$C and 77% to 95% respectively obtained in the sampled sites during the course of this study revealed that the period of study provided a favourable condition for the optimum growth of fungi of most species. (Danny *et al.*, 1998; Araujo and Rodrigues, 2004). Brickus *et al* (1998) reported that high indoor humidity leads to dampness and low indoor humidity (less than 30%) which causes mucus membrane irritation, dry eyes, and sinus discomfort. The average indoor air temperature and relative humidity values obtained in the study were above the stipulated guidelines prescribed by the Institute of Environmental Epidemiology (IEE, 1996). Arundel *et al.* (1986) reported that a combination of high humidity and high temperatures thus influence the reduction of the rate of evaporative cooling of the body resulting to considerable thermal discomfort.

**Conclusion**

The assessment of the indoor air quality of the halls of residence examined revealed that the enumerated and isolated mycoflora were common fungi species associated with indoor air environment. From the results obtained in this study, it is inferred that the building design had no significant effect on the indoor airborne fungal concentration as much as did the occupants density, temperature and relative humidity of the sampling sites owing to the observed insignificant difference observed in the mean indoor airborne fungal counts of the two halls examined. The mean temperature and relative humidity values recorded were observed to be higher than the permissible limit values stipulated by the Institute of Environmental Epidemiology (IEE, 1996) for indoor air quality. This difference suggests poor thermal comfort in the two halls of residence studied. It is recommended that the Management in charge of hostel accommodation ensures that the rooms in the halls of residence follow the designed occupant capacity since thermal comfort is influenced by personal activities in addition to indoor temperature and relative humidity. The School's Management is advised to set aside a sanitation day solely for the cleaning and maintenance of the hostel premises to reduce the availability of substrate for fungal growth. In view of the contributions of outdoor airborne fungal concentration to the indoor air quality, research work should be encouraged to ascertain the mycological content of the surrounding outdoor air of these halls.

**References**

Araujo, R. and Rodrigues, A. (2004). Variability of germinative potential among pathogenic species of *Aspergillus*. *Journal of Clinical Microbiology* **42**: 4335 - 4337.

Araujo, R., Cabral, J. and Rodrigues, A. (2008). Air filtration systems and restrictive access conditions improve indoor air quality in clinical units: *Penicillium* as a general indicator of hospital indoor fungal levels. *American Journal of Infection Control* **36**: 129-134.

Arundel, A. , Sterling, E., Biggin, J. and Sterling, J. (1986). Indirect health effects of relative humidity in indoor environments. *Environmental. Health Perspectives* **65** : 351-361.
Ayanbimpe, G., Wapmera, S. and Kuchin, D. (2010). Indoor air mycoflora of residential dwellings in Jos metropolis. *African Health Sciences* **10** : 172-176
Barnett, H. and Hunter, B. (1998). *Illustrated Genera of Imperfect Fungi*. Fourth Edn. Burgess Publishing Co. New York. 218pp.
Brickus , L., Cardoso,J., amd Francisco ,R. (1998) . Distributions of Indoor and Outdoor Air pollutants in Rio de janeiro ,Brazil: Implications to Indoor Air Quality in Baysides Offices. *Environmental Science and Technology* **32 :** 3485 - 3490
Buttner, M., Willeke, K. and Grinshpun, S. (1997). Sampling and analysis of airborne microorganism.pp.177- 179 **In:** Hurst ChJ (Eds): *Manual of Environmental Microbiology*. ASM Press, Wasinghton D.C. New York.
Curtis, L., Cali, S., Conroy, L., Baker, K. Ou, C. , Hershow, R., Norlock-Cruz, F. and Scheff, P. (2005). *Aspergillus* surveillance project at a large tertiary-care hospital. *Journal of Hospital Infection* **59:** 188-196.
Danny, J., Wing, C., Jumper, A. and David, C. (1998). Correlation between the prevalence of Certain fungi and sick building syndrome. *Occupational Environmental Medicine* **55**:579 - 584
Douwes, J. (2009). Building dampness and its effect on indoor exposure to biological and non-biological pollutants, In: *Dampness and Mould*, 7-29, WHO Europe, ISBN 978-92-890-4168-3, Copenhagen. 115 pp.
Dutkiewicz, J. and Augustowska, M. (2006). Variability of airborne microflora in a hospital ward with a period of one year. *Annals of Agriculture, Environment and Medicine.* 13: 99 - 106
Ekhaise, F., Ighosewe, O. and Ajakpovi, O.(2008).Hospital Indoor Airborne Microflora in Private and Government Owned Hospitals in Benin city, Nigeria. *World Journal of Medical Sciences* **3**:34 - 38.
Fink, J., Banaszak , E., Thiede , W. and Barboriak, J.(1971).Interstitial Pneumonitis due to Hypersentivity to an organism Contaminating a heating System. *Annual International Medicine* **20**:74 - 80.
Flannigan, B. (1997). Air sampling for fungi in indoor environments. *Journal of Aerosol Science* **28**: 381 - 392.
Grant, C. (1989). The moisture requirements of moulds isolated from domestic dwellings. *International Biodeterioration and Biodegradation* **25**:259 – 284.
Horner, W. , Worthan , A. and Morey, P. R. (2004).. Air and dustborne mycoflora in houses free of water damage and fungal growth. *Applied and Environmental Microbiology* **70** : 6394 - 6400
Institute of Environmental Epidemiology (IEE) (1996). *Guidelines for Good Indoor air quality in Office Premises*. IEE, Ministry of Environment. Singapore. 49 pp.
Jaffal, A., Banat, I., Mogheth, E., Nsanze, H.,Banar ,A. and Ameen A.(1997).Residential Indoor Airborne Microbial Population in United Arab Emirates. *Environmental International* **23**:529 - 533 .
Kasprzyk, I. (2008). Aeromycology - Main research field of interest during the last 25 years. *Annual Agric Environment Medicine*. **15**: 1 - 7
Kosak, P., Gallup, J, Cummins, L and Gillman, S.(1985). Endogenous mould exposure: Environmental risk to atopic and non atopic patients.pp.149- 170 .In :Gammage, R. and Kay, V.(eds).Indoor air and human health .Lewis Publishers,Chelsea, Michigan.
Krzysztofik, B. (1992). *Mikrobiologia powietrza*. Wydawnictwo Politechniki Warszawskiej, Warszawa **3** : 19-30.
Latika, B. and Ritu, V.(2010). Hospital Indoor Airborne Microflora in Private and Government Owned Hospitals in Sagar city,India. *World Journal of Medical Sciences* **5**: 65 - 70.
Miller, J., Laflamme, A, Sobol, Y., Lafontaine F. and Greenalgh, R.(1988). Fungi and fungal products in some Canadian houses. *International Biodeterioration* **24** : 103 - 120
Nielsen, K. (2003). Mycotoxin production by indoor moulds. *Fungal Genetics and Biology* **39** : 103 - 177.
Obbard , J . and Fang, L . (2003). Airborne concentrations of bacteria in a hospital environment in Singapore. *Water, Air, and Soil Pollution* **144** : 333 - 341.
Ogórek R., Kalinowska, K., and Pląskowska E., (2011): *Mycological air pollutions on different culture mediums in selected rooms of Dermatology Department. Part I.. Mikologia Lekarska* **18**: 30 - 38.
Stryjakowska-Sekulsa, A., Piotraszewska-Pajak,Szyszka, A., Nowicki, A and Filipiak, M. (2007). Microbiological Quality of Indoor Air in University Rooms. *Polish Journal of Environmental Studies* **16** : 623 - 632.
Wemedo,S., Ede ,P. and Chuku ,A. (2012). Interaction between building Design and Indoor Airborne Microbial Load in Nigeria. *Asian Journal of Biological Sciences* **5** : 183 -191
Yassin, M. and Almouquatea , S. (2010). Assessment of airborne bacteria and fungi in an indoor and outdoor environment. *International Journal of Environmental Science and Technology* ***7*** : 535 – 544.