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Microbiological Indoor Air Quality of Male Student Hostels in University of Benin, (Ugbowo Campus), Benin City, Nigeria.

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ABSTRACT: *The microbial bioload of the indoor air environment in two (2) male student hostels (Hall 3 and 4), University of Benin, Benin City were evaluated using the settle plate methods. The duration of the study was between September, 2011 and February, 2012. The antibiogram of the bacterial isolates was ascertained using the disc diffusion methods and molecular biological techniques to determine the presence of plasmids harbored by the bacterial isolates. The airborne heterotrophic bacterial counts in Hall 3 hostel between within the study duration ranged from 0.44 ± 0.5 × 10^3 cfu/m^3 to 8.6 ±1.2 × 10^3 cfu/m^3 in the morning and 0.35 ±0.4 × 10^3 cfu/m^3 to 9.8 ±0.6 × 10^3 cfu/m^3 in the afternoon. The airborne heterotrophic bacterial counts in Hall 4 hostel within the study duration ranged from 0.29± 0.5 × 10^3 cfu/m^3 to 2.7± 1.1 × 10^3 cfu/m^3 in the morning and 0.45 ± 0.7 × 10^3 cfu/m^3 to 2.4±3.1× 10^3 cfu/m^3 in the afternoon. The airborne heterotrophic fungal counts in the morning and afternoon periods in Hall 3 hostel between September, 2011 and February, 2012 ranged from 0.32 ± 1.1 × 10^3 cfu/m^3 to 1.4 ± 0.6 × 10^3 cfu/m^3 and 0.38 ± 0.2 × 10^3 cfu/m^3 to 1.4 ± 0.8 × 10^3 cfu/m^3 respectively, while the airborne heterotrophic fungal counts in Hall 4 hostel between September, 2011 and February, 2012 ranged from 0.29 ± 0.4 × 10^3 cfu/m^3 to 1.9 ± 0.6 × 10^3 cfu/m^3 in the morning and 0.27 ±.3 0 × 10^3 cfu/m^3 to 6.8± 2.0 × 10^3 cfu/m^3 in the afternoon. There was no significant difference ($P > 0.05$) between the morning and afternoon airborne microbial counts observed in Hall 3 hostel obtained in the months of November, 2011 and February, 2012. The differences in the airborne bacterial counts obtained in Hall 3 and 4 hostels in the months of September, 2011, October, 2011 and January, 2012 were significant ($P < 0.05$). Seven airborne bacterial and nine fungal isolates were obtained and identified from the halls of residence. Among the airborne bacterial isolates, Enterobacter aerogenes (64%) had the highest percentage frequency of occurrence and distribution, while S. epidermidis (14%) had the least percentage frequency of occurrence and distribution. While among the airborne fungal isolates, Aspergillus niger (94%), P. chrysogenum (94%) and Aspergillus veriscolor (98%) were the most frequently occurring isolates in the indoor air environment in Hall 3 and Hall 4. S. cerevisiae (5%) had the least percentage of occurrence and distribution amongst the fungal isolates. The bacterial isolates displayed resistance against cloxacillin and cefuroxine while Escherichia coli exhibited sensitivity against augumentin, ofloxacin, ciprofloxacin and erythromycin. Staphylococcus epidermidis, Klebsiella spp., Micrococcus spp. and Enterobacter aerogenes, all harboured plasmids, while no plasmid was detected for Bacillus spp. and Escherichia coli. The indoor air temperature recorded range from 27^{0}C to 30^{0}C in the morning and 28^{0}C to 31^{0}C in the afternoon for Hall 3, 27^{0}C to 31^{0}C in the morning and 28^{0}C to 31^{0}C in the afternoon for Hall 4. The relative humidity ranged from 66% to 69% in the morning and 68% to 71% for Hall 3, while in Hall 4 it ranged from 68% to 70% in the morning and 68% to 71% in the afternoon. Anthropogenic activities were observed to positively influence the number and diversity of the indoor microbial population of the two hostels. Physical attributes such as temperature and relative humidity, of the indoor air in the respective hostels were poor, suggesting that the overall thermal comforts within these hostels were very poor.*

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

Introduction

Microorganisms such as bacterial and fungal spores are almost always present in the air. The quality of indoor air environment, however, is not easily defined or readily controlled, and can potentially place human occupants at risk (1). Exposure to bio-aerosols, containing airborne microorganisms and their byproducts can result in respiratory disorders and other adverse health effects such as infections, hypersensitivity pneumonitis and toxic reactions (2).

Microbial risk and threat in indoor/outdoor areas is caused most frequently by molds and bacteria. In the environment, spores of molds and bacteria may become airborne and are therefore ubiquitous. The relative humidity and/ or the moisture content of the materials determine what extent different microorganisms are able to grow on indoor or outdoor materials (3). The adverse effect of microorganisms in the indoor environment is influence by their concentration and the proper conditions for growth, such as high humidity and suitable temperature.

Microorganisms present in the air originate from soil, plants and water, and atmospheric air is not a convenient environment for their growth. However, spore-forming bacteria and fungi are able to survive as bio-aerosols and stay viable for a long time in the air due to high humidity and suitable temperature (3). Study of airborne microorganisms and their impact on human, animal and plant life is a main interest of a new area of biology and interdisciplinary science aerobiology.

Many microorganisms present in the air, including viruses, bacteria, fungi, yeasts and protozoa, have been are associated with diseases occurring in humans, plants and animals. It is generally known that microorganisms present in the air can affect human health, causing mainly respiratory and related diseases transmitted via respiratory route. Many species of bacteria such as *Streptococcus pyogenes, Mycobacterium tuberculosis, Legionella pneumophila* or viruses are known to cause diverse severe human infections and diseases (2).

Moisture damage and microbial growth indoors are associated with adverse health effects among the occupants (4). Dampness or moisture damage is a common problem in buildings all over the world. In Finland, 70 % of day care centers (5), as well as 55 % of homes (6) and 53 % of schools (7) showed signs of moisture problems. High moisture load in a building can also be found in repeatedly damp facilities, such as institutional kitchens, which may lead to microbial growth on surfaces and structures. There are however, few studies, which have evaluated microbial deterioration in these kinds of facilities. When building or surface materials become wet due to moisture damage, it is only a matter of time before microbes will start to grow. In fact, moisture is often the growth-limiting factor for microbes, since the other critical factors such as nutrients and suitable temperatures are usually fulfilled (7).

There exist a number of methods for the detection of viable airborne microorganisms. The quantitative determination of airborne microorganisms are possible by sedimentation also known as the settle plate methods, impaction on solid surfaces, impingement in liquids, filtration, centrifugation, electrostatic precipitation and thermal precipitation (8). It is important to recognize that no single sampler can be used for sampling and analysing all bioaerosols. Factors that must be considered during the selection of an appropriate sampling method include, sampling environment, analysis methods used and monitoring objectives (8; 9).

The objectives of this study were to enumerate, characterized and identify airborne microorganisms associated with the indoor quality of air and hygienic conditions of the University of Benin male studentôs hostels in Benin City, Nigeria.

Materials and Methods

Study location

The study was carried out in two male student hostels in University of Benin, Ugbowo Campus, Benin City. They were Hall three (3) and Hall four (4) hostels. Five (5) different units were earmarked for the study and they include sleeping rooms, corridors, common rooms, bathrooms and toilets.

Preparation of culture media

The culture media were prepared according to the manufacturerôs instructions. After preparation, the media were dispensed into sterile Petri dishes for adequate exposure in the units stipulated for the study.

Sample collection and microbiological examinations

The airborne samples were collected from the five different units in the two halls of residence using the settle plate methods which involved the exposure of prepared plates. The plates containing nutrient agar (NA), Mac Conkey agar (MCA) and potato dextrose agar (PDA) were used for the enumeration and isolation of airborne bacterial and fungal isolates respectively. The nutrient agar medium was supplemented with antifungal agent (Griseofulvin) to inhibit the growth of fungi while the potato dextrose agar was supplemented with antibiotic (Chloramphenicol) to inhibit the growth of bacteria. The plates were exposed and placed on platforms of one meter (1m) above the ground floor to stimulate the human breathing zone at the respective sampling point for a period of 10 minutes. Duplicates of the plates were exposed at the required time between 8.00am and 10.00am for morning and 1.00pm to 3.00pm for afternoon in the different sampling units at a suitable position in the sampling room. Samples were collected between September, 2011 and February 2012. After exposure, the plates were collected and taken to the laboratory for microbiological examinations. The plates were incubated at 37^0C for 24 - 48hr for bacterial isolates and at room temperature (20^0C ï 28^0C) for 3 - 4 days for the growth of fungal isolates. After incubation, the total number of colony forming units (cfu) for the bacterial and fungal airborne isolates were enumerated and recorded as colony forming units per meter square.

Quantitative enumeration of the airborne bacterial and fungal isolates

The qualitative determination of the airborne bacterial isolates was determined according to the methods of Bhatia and Vishwakarma (2010).

The airborne microbial counts were expressed as cfu/m^3 = $\frac{a.10,000}{p.t.0.5}$,

a – no of colonies, p = surface area of plates and t = times of exposure

Determination of temperature and relative humidity of the sampling areas

The temperature and relative humidity of the sampling areas of the two hostels (Hall 3and Hall 4) were determined at each sampling time using mercury thermometer bulb and hygrometer.

Qualitative determination of airborne bacterial isolates

The cultural characteristics of the airborne bacterial isolates such as size, shape, colour, elevation, surface and optical appearance were observed during examination. Representative isolates were further sub-cultured onto nutrient agar before finally being transferred to nutrient broth in McCartney bottles and stored in refrigerators. Morphological characteristics such as Gram staining, cell arrangement and motility were examined. The biochemical examination and characterization of the representative airborne bacterial isolates were carried out using the standard microbiological method for identification of bacterial species according to Bergeyôs Mannal of Determinative Bacteriology, Buchanan and Gibbons (1974).

Qualitative determination of airborne fungal isolates

The purified fungal isolates were identified through observation of their colonies, microscopic examination of the respective spores and hyphal appendages using wet mount technique (lactophenol cotton blue preparation and distilled water serving as mutants) and results of the microscopic observation were drawn according to the methods of Barnett and Hunter (1972).

Determination of the antibiogram of the airborne bacterial isolates

The respective purified bacterial isolates were transferred to sterile peptone water under aseptic conditions and incubated for about 10 hours. The turbidities of the broth cultures were adjusted to match an opacity standard (Barium sulphate and Tetraoxosulphate (VI) acid solution). The resulting broth culture had a microbial cell density of about 10^6 cfu. Muller Hinton agar plates were prepared and appropriately labeled. The plates were inoculated with the standardized microbial broth cultures by spread plate techniques (13). The inoculated plates were left to dry for 30 minutes. Commercially available antibiotic discs containing varying concentrations of various types of antibiotics were placed at adequate distances on each of the seeded agar plates with the aid of sterile forceps. These plates were incubated for 12 hours. The resultant visible zones of inhibition were measured. Distances lesser than 14 mm were regarded as resistant (R), while distances which ranged from 14 mm to 17 mm were indicated as intermediate (I). Also, zones of inhibition greater than 17 mm were recorded as susceptible (S) for the respective isolates (13).

Determination of the plasmid profile of the bacterial isolates.

Plasmid isolation and extraction

Confluent (one plate per DNA sample) lawn of the bacterial culture were collected by sweeping with a glass rod and were resuspended in 100 µl of PEB 1 (50 mM glucose- 10 mM Ethylene dinitrilo tetra-acetic acid (EDTA)at 0 ^{0}C in a 1.5 ml Eppendorf tube. After 10 minutes, 200 µl of PEB II (0.2 N Sodium hydroxide- 1% Sodium Dodecyl Sulphate) at room temperature was added and mixed gently by inversion several times. After 5 minutes of incubation at 0^0 C, 150 µl of PEB III (3 M Potassium acetate- 1.8 M Formic acid) at room temperature was added, mixed gently several times, and incubated for 15 minutes at 0^0C. About 1.5 ml of the PEB culture broth was spun for 1 minute in a micro-centrifuge to form pellet cells. The supernatant was gently decanted leaving 50 ï 100 µl together with cell pellet and vortexed at high speed to resuspend cells completely. Three hundred (300) µl of TENS (Tris 25mM, EDTA 10mM, NaOH 0.1N and SDS 0.5%) was added and mixed by inverting the tubes 3 ï 5 times until the mixture became sticky. About 150 µl of 3.0M sodium acetate (pH 5.2) was added and vortexed to mix completely. The solution was spun for 5 minutes in the micro-centrifuge to pellet cell debris and chromosomal DNA and the supernatant transferred into a fresh tube, mixed well with 900 µl of ice cold absolute ethanol. It is spun to pellet plasmid DNA (white pellet was observed). The supernatant discarded and the pellet rinsed twice with 1 ml of 70% ethanol and dried. The pellets were re-suspended in 20 ï 40 µl of TE buffer or distilled water for further use (14).

Agarose gel electrophoresis

Agarose powder was weighed out (0.8g) and then 100 ml of 1x TBE buffer was added and dissolved by boiling using a magnetic stirrer. It was allowed to cool to about 60^0C then 10 µl of ethidium bromide was added and mixed gently. It was poured into the electrophoretic tank with the comb in place to obtain a gel of even thickness and to avoid bubbles. It was then allowed to solidify for 20 minutes and the comb removed. The tray was placed in the electrophoretic tank and 1X TBE buffer poured into the tank ensuring that the buffer covered the surface of the gel. About 15 µl of the sample was mixed with 2 µl of the loading dye and carefully loaded into the wells created by the comb. The electrodes were connected to the power pack in such a way that the negative terminal is at the end were the sample was loaded. Electrophoresis was run at 60 ï

100 V until the loading dye migrated about three-quarters of the gel. The electrophoresis was then turned off and the electrodes disconnected and the gel was observed on a UV- trans illuminator (15)

Statistical analysis

The data obtained were subjected to statistical analysis using the unpaired T-test; Two sample assuming equal variance analysis (16).

Results

The results of the microbial bioload of the indoor air environments in sampled areas in the male hostels of Hall 3 and 4 between September 2011 and February, 2012 are presented in Tables 1 ï 6. The morning and afternoon airborne heterotrophic bacterial counts in Hall 3 male student hostel between September, 2011 and February, 2012 ranged from $0.44 \pm 0.5 \times 10^3$ cfu/m^3 to $8.6 \pm 1.2 \times 10^3$ cfu/m^3 and $0.35 \pm 0.4 \times 10^3$ cfu/m^3 to $9.8 \pm 0.6 \times 10^3$ cfu/m^3 respectively (Table 1). The morning and afternoon airborne heterotrophic bacterial counts in Hall 4 male student hostel between September, 2011 and February, 2012 ranged from $0.29 \pm 0.5 \times 10^3$ cfu/m^3 to $2.7 \pm 1.1 \times 10^3$ cfu/m^3 and $0.45 \pm 0.7 \times 10^3$ cfu/m^3 to $2.4 \pm 3.1 \times 10^3$ cfu/m^3 respectively (Table 2). The morning and afternoon airborne coliform counts in Hall 3 male student hostel between September, 2011 and February, 2012 ranged from $0.29 \pm 0.1 \times 10^3$ cfu/m^3 to $2.2 \pm 1.0 \times 10^3$ cfu/m^3 and $0.35 \pm 0.7 \times 10^3$ cfu/m^3 to $2.7 \pm 4.6 \times 10^3$ cfu/m^3 respectively (Table 3). The morning and afternoon airborne coliform counts in Hall 4 male student hostel between September, 2011 and February, 2012 ranged from $0.39 \pm 0.8 \times 10^3$ cfu/m^3 to $2.3 \pm 1.4 \times 10^3$ cfu/m^3 and $0.31 \pm 0.6 \times 10^3$ cfu/m^3 to $2.9 \pm 2.0 \times 10^3$ cfu/m^3 respectively (Table 4). The morning and afternoon airborne heterotrophic fungal counts in Hall 3 male student hostel between September, 2011 and February, 2012 ranged from $0.32 \pm 1.1 \times 10^3$ cfu/m^3 to $1.4 \pm 0.6 \times 10^3$ cfu/m^3 and $0.38 \pm 0.2 \times 10^3$ cfu/m^3 to $1.4 \pm 0.8 \times 10^3$ cfu/m^3 respectively (Table 5). The morning and afternoon airborne heterotrophic fungal counts in Hall 4 male student hostel between September, 2011 and February, 2012 ranged from $0.29 \pm 0.4 \times 10^3$ cfu/m^3 to $1.9 \pm 0.6 \times 10^3$ cfu/m^3 and $0.27 \pm 0.3 \times 10^3$ cfu/m^3 to $6.8 \pm 2.0 \times 10^3$ cfu/m^3 respectively (Table 6).

Seven airborne bacterial isolates were obtained and identified. They include *Bacillus* spp., *Escherichia coli*, *Staphylococcus epidermidis*, *Serratia marcescens*, *Enterobacter aerogenes, Micrococcus* spp. and *Klebsiella* spp. (Table 7). Nine airborne fungal isolates were obtained and identified. They include *Mucor mucedo*, *Rhizopus* spp., *Aspergillus niger*, *Aspergillus versicolor*, *Candida* spp., *Saccharomyces cerevisiae*, *Penicillium chrysogenum, Rhodotorula* spp. and *Penicillium* spp. (Table 8). *Enterobacter aerogenes* (68%) had the highest percentage frequency of occurrence and distribution amongst the airborne bacterial isolates while *S. epidermidis* (14%) had the least percentage frequency of occurrence (Table 7). *Aspergillus versicolor* (98%) was the most predominant fungal isolate in the indoor air environments in Hall 4 and *A. niger* (94%) and *P. chrysogenum* (94%) were the most frequently occurring isolates in Hall 3 (Table 8). *S. cerevisiae* had the least percentage of occurrence and distribution (5%) amongst the airborne fungal isolates (Table 8).

The results of the plasmid profiling of the bacterial isolates are presented in Figure 1. *Staphylococcus epidermidis*, *Klebsiella* spp., *Micrococcus* spp., *Enterobacter aerogenes* haboured plasmids, while no plasmids were detected for *Bacillus* spp. and *Escherichia coli* (Figure 1).

The antibiogram profiles of the airborne bacterial isolates are presented in Table 9. All isolates recorded were observed to be resistant against cloxacillin and cefuroxine while *Escherichia coli* exhibited sensitivity against augumentin, ofloxacin, ciprofloxacin and erythromycin (Table 9).

The mean temperature and relative humidity readings of the indoor air in the sampled areas of the male student hostels (Hall 3 and 4) are presented in Tables 10 and 11. The morning and afternoon temperature and relative humidity readings obtained from Hall 3 male student hostel ranged from 27 ^{0}C to 30 ^{0}C , 66 % to 69 %, 28 ^{0}C to 31 ^{0}C and 68 % to 71 % respectively (Table 10). The morning and afternoon temperature and relative humidity readings obtained from Hall 4 male student hostel ranged from 27 ^{0}C to 31 ^{0}C , 68 % to 70 %, 28 ^{0}C to 31 ^{0}C and 68 % to 71 % respectively (Table 11).

Table 1: Bacterial counts of indoor air environment in Hall 3 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3 ± S.D) .

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm
A105	2.7 ±1.0	1.7 ± 1.2	1.7± 1.4	0.71 ± 0.4	1.8 ± 2.9	0.71 ± 0.4	1.1 ±0.5	1.1 ±1.2	1.2± 0.6	1.7 ±1.7	1.6± 4.0	1.8± 1.6
A205	2.1±3.2	1.9 ±1.9	1.5 ± 0.5	0.59 ± 0.7	2.0 ± 18.4	1.1 ± 1.9	1.5±3.6	1.4 ±0.9	1.2 ±0.9	1.5 ±3.0	1.2 ± 1.2	2.3 ±4.0
A305	2.1±2.3	1.0± 0.6	1.3 ±1.5	0.65 ± 0.4	2.4 ± 19.1	1.0 ± 2.1	1.3 ±3.1	1.7 ±2.8	0.81±2.4	1.7 ±2.9	1.5 ±1.6	2.0 ±3.0
B105	2.0±1.4	1.2 ± 1.1	1.1 ±0.8	1.1± 0.4	2.1 ± 14.6	0.81 ± 0.8	0.88 ±1.4	0.82 ±1.4	0.77±2.1	1.2 ± 2.4	1.0 ± 1.4	1.7 ±1.2
B205	2.1±2.3	0.97±3.8	1.6± 1.3	1.3 ± 1.2	1.5 ± 21.6	0.78 ± 1.4	0.72 ±1.7	0.81 ±1.4	1.2 ±1.6	1.4 ±2.4	1.1 ±0.6	1.9 ±4.0
B305	2.3±2.4	1.1 ±4.3	2.2 ± 1.3	0.99 ± 0.4	2.1 ± 10.7	0.93 ± 2.2	0.92 ±0.7	0.92 ±0.7	0.93±0.8	1.4 ±0.7	1.6 ±1.2	1.1 ±2.0
C105	1.8 ± 0.3	0.98 ±1.0	1.6±4.4	0.61 ± 0.9	1.9 ± 23.1	0.90 ±2.6	1.2 ±1.1	0.96 ±0.8	0.97±1.0	1.3 ±0.8	1.6 ± 4.0	1.9 ±2.1
C205	2.2 ±0.7	2.2 ±2.1	2.3±2.0	0.51 ± 0.3	2.1 ± 15.5	0.96 ± 0.9	0.85⊥2.8	1.4 ⊥0.4	1.3 ⊥0.4	1.2 ⊥1.0	1.0 ±1.5	2.2 ⊥1.6
C305	2.3±2.8	1.8 ±4.0	1.5 ±2.0	0.77 ± 0.6	2.2 ± 19.0	0.74 ± 1.4	0.88±2.5	1.7 ±1.7	1.2 ±2.3	1.4 ±3.6	1.6 ±0.6	1.8 ±3.5
D105	2.3±3.8	1.9 ±3.5	1.2 ±1.4	0.71 ± 0.2	1.2 ± 7.0	0.77 ± 0.7	0.60 ±0.8	1.0 ±0.5	1.1 ±1.7	2.2 ±2.2	1.0 ±0.2	2.2 ±3.0
D205	2.2±3.8	1.9 ±4.0	1.4 ± 1.0	0.67 ± 0.5	1.8 ± 9.6	0.77 ⊥1.3	0.99 ⊥0.6	0.7⊥2.0	1.1 ⊥2.1	2.7 ⊥2.3	0.60 ⊥2.0	1.7 ⊥4.0
D305	1.7 ± 1.4	1.5 ±1.8	1.2 ±1.5	0.78 ±0.9	1.8 ± 16.5	1.2 ±0.7	1.1 ±0.5	0.4±1.8	1.2 ±0.2	1.8 ±0.6	1.3 ±3.0	1.5 ±1.6
E105	6.6 ± 1.8	0.99±4.0	1.3 ± 1.3	0.65 ± 0.9	1.2 ± 10.2	0.61 ±0.5	0.82 ±1.4	0.7±1.8	0.95±2.1	2.5 ±0.6	0.53±0.6	0.99 ±0.2
E205	1.1±4.5	1.4 ± 1.2	2.2±2.4	0.57 ± 0.9	1.8 ± 13.3	0.79⊥1.5	1.0 ⊥0.3	1.1 ⊥0.9	0.44⊥0.5	1.7 ⊥4.3	8.6 ⊥1.2	0.99 ⊥1.2
E305	1.5 ± 3.7	1.7 ±3.5	2.2±4.8	0.81 ± 0.8	1.4 ± 8.3	0.90 ±1.2	1.7 ±2.6	1.2 ±0.8	0.48±1.2	2.4 ±4.3	0.71 ±0.2	2.6 ±1.2
F105	2.6 ± 1.7	1.3 ±2.9	1.6±3.1	0.35 ± 0.4	1.3 ± 8.4	0.95 ±1.4	1.4 ±2.4	1.6 ±0.8	0.65±2.8	1.6 ±1.3	1.4 ±1.3	1.9 ±4.2
F205	1.6 ±0.9	1.4 ±4.6	1.3 ±1.3	0.70 ± 1.0	1.0 ± 7.4	0.74 ⊥0.8	1.7 ⊥2.5	2.2 ⊥1.6	1.2 ⊥0.2	1.7 ⊥2.1	0.96 ⊥0.4	1.2 ⊥1.6
F305	2.2±2.3	1.9 ±2.9	1.7 ±1.0	0.64 ± 0.2	1.2 ± 12.5	0.74±1.5	0.86 ±0.8	2.1 ±4.8	0.85±2.0	1.1 ±0.5	1.5 ±3.6	1.2 ±0.1
C R	2.6±2.3	1.1 ± 0.9	2.3±4.1	1.1 ± 1.1	1.8 ± 14.6	1.7 ±0.4	1.6 ±1.9	1.9 ±4.0	1.7 ±2.6	1.6 ±3.5	1.8 ±1.2	1.5 ±0.4
Toilet	2.1±2.1	0.82 ± 0.9	1.7±2.6	0.78 ± 0.4	1.1 ± 12.9	9.8 ±0.6	1.0 ±0.5	1.0 ±0.2	1.1 ±0.3	2.4 ±0.7	1.8 ±1.3	1.5 ±1.5
Bathroom	1.7±4.2	1.2 ± 1.4	1.6±3.7	0.57 ± 0.4	0.9± 14	0.99 ±0.4	0.88 ±1.2	1.2 ±1.1	0.96±0.1	1.5 ±3.2	1.5 ±1.7	1.5 ±4.0
Corridor	2.0 ±1.1	1.3 ±2.4	1.4 ± 0.6	0.71 ± 0.4	1.1 ± 9.0	1.1 ±2.1	0.86 ±1.3	0.79 ±1.3	0.88±1.3	1.4± 1.3	1.5 ±1.2	1.7 ±3.8

Key: CR: Common room,
A105 - F305: Residential rooms

Table 2: Bacterial counts of indoor air environment in Hall 4 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3 ± S.D) .

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm
R1	1.7 ± 1.6	0.73±0.3	0.90± 1.0	1.0 ± 0.3	1.6±1.1	1.4±1.1	1.9±3.5	1.2±2.4	2.5±1.0	1.1±2.3	1.2 ±1.0	1.4 ±3.6
R 2	1.9 ± 0.6	0.65±0.6	1.5 ±1.8	1.6 ±4.2	1.1±0.8	1.8±2.8	1.8±3.5	0.98±2.6	1.8±3.1	1.3±1.2	0.91 ±0.4	1.5 ±3.2
R 3	1.4 ± 1.4	1.1 ± 1.4	1.7 ± 1.4	1.8 ±0.8	0.93±0.6	1.5±3.1	1.6±2.6	0.96±2.0	2.4 ±3.3	1.5±2.0	1.2 ±1.2	1.6±1.8
R 4	1.3 ± 0.6	1.1± 1.6	1.4 ± 1.4	1.1 ± 0.8	1.6±1.0	1.3±3.2	1.5±2.2	1.1±2.6	0.87±1.2	1.3±3.3	0.81±0.4	1.6±2.6
R 5	1.3 ± 0.6	0.65±0.6	1.7± 3.1	1.1 ± 2.3	1.3±0.2	0.91 ±1.2	1.3±2.2	1.0±1.6	1.8±4.8	0.96±0.8	1.0±3.1	1.4 ±1.0
R 6	1.7±2.2.	0.60±1.1	1.6± 4.5	1.9 ± 1.0	1.7±1.1	0.86±1.4	1.4±2.6	1.0±2.0	1.4 ±1.1	1.3±4.2	0.29 ±0.5	1.6±2..6
R 7	2.2 ± 0.8	0.98±0.8	1.0± 2.2	2.2 ± 1.2	1.6±2.0	0.63±1.4	2.3±1.1	1.0±0.8	1.6 ±4.0	0.74±1.8	0.52±0.6	0.86±0.6
R 8	2.2±2.0	1.0 ± 0.3	0.80± 1.6	2.1 ± 2.4	1.2±2.3	1.9±3.6	1.4±4.6	0.75±0.6	1.3 ±0.8	0.67±2.2	0.56±0.5	1.2 ± 1.2
R 9	1.7 ± 1.6	0.75±0.4	0.96± 1.0	1.7 ± 4.5	0.84±2.6	1.5±2.6	1.1±0.4	0.98±1.0	0.98 ±2.0	0.53±0.8	0.57±0.6	1.0 ±0.5
R10	1.8±4.0	0.72±1.6	1.0± 1.8	2.2 ± 0.2	1.0±2.0	1.9±3.1	1.5±2.8	1.2±1.6	2.0 ±4.2	1.6±2.4	0.78±0.8	1.5±1.8
R 11	2.0±3.0	0.78± 1.1	0.98 ±0.2	1.9 ± 4.0	1.4±0.8	1.2 ±1.0	1.8±3.5	0.91±0.6	2.2 ±4.3	1.1±3.1	0.80±1.8	1.6±2.4
R 12	1.2 ± 1.1	0.59±1.0	1.5 ± 3.3	1.2± 1.1	1.3±2.2	1.3±3.5	1.1±3.3	1.3±1.1	2.5 ±2.8	0.87±1.0	0.51±0.3	1.0±1.1
R 13	1.3 ± 0.8	0.80±1.0	1.6 ± 0.6	1.7± 4.4	1.2±1.1	0.88± 1.1	0.95±0.8	1.2±2.4	1.3 ±1.1	1.6±2.3	0.75±1.2	0.81 ±0.5
R 14	1.7±4.0	1.1 ± 0.2	0.90 ± 1.2	1.9± 2.0	1.1±0.4	1.3±1.1	0.90±0.6	0.71±2.0	1.1 ±0.8	0.98±1.0	0.80±1.2	0.47±0.7
R 15	0.96±1.2	1.0 ± 0.2	0.75 ± 0.4	1.8± 1.6	1.2±1.1	1.1 ±1.6	0.95±0.6	0.45±0.8	1.5 ±1.0	0.77±2.8	0.95±0.6	1.1±1.8
R 16	0.86± 0.8	0.85±1.1	1.0 ± 0.4	1.9± 0.8	1.4±1.4	1.6±2.8	1.0±0.4	0.63±2.0	1.6 ±0.8	1.0±2.4	0.40±0.6	1.1±2.4
R 17	2.4 ± 0.8	0.63±0.4	0.96±2.3	1.4± 2.2	1.4±3.3	1.5±2.6	1.9±3.6	0.74±1.2	1.5 ±1.4	1.3±3.0	0.41±0.4	1.2±1.4
R 18	1.3 ± 1.2	0.74±0.6	0.57 ±0.4	2.1 ± 2.5	0.61±0.6	1.6 ±0.8	0.86±0.2	1.1±2.2	2.6 ±2.4	1.2±1.1	1.0±2.6	1.4 ±1.2
C R	2.4 ± 1.0	0.74±0.8	0.42 ± 0.8	1.5 ± 2.2	1.5±1.4	0.86 ±1.2	1.0±0.2	1.8±2.3	2.7 ±1.1	1.6±1.6	0.93 ±1.4	1.9±3.2
Toilet	1.9 ± 0.8.	0.72±0.6.	0.92±2.0	1.3 ± 2.3	1.3±2.8	1.1±1.8	2.3±1.4	1.2±1.6	2.0 ±4.2	1.5±4.2	1.0±2.0	1.8±1.2
Bathroom	1.3 ± 0.4	1.1 ± 1.6	1.5 ± 1.6	2.0 ± 2.4	1.3±2.2	0.96±2.2	1.9±2.4	0.66±2.0	2.2 ±3.6	1.2±4.2	0.73±1.8	2.4±3.1
Corridor	0.85±1.0	0.87±0.6	1.3 ± 2.0	2.2 ± 1.1	1.2±1.1	0.92± 0.8	0.98±0.8	0.78±0.8	2.1± 2.2	0.78±3.5	0.66 ±0.6	1.5±3.5

Key: CR: Common Room,
R1 - R18: Residential Rooms

Table 3: Coliform counts of indoor air environment in Hall 3 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3 ± S.D) in MacConkey Agar.

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	am	pm	Am	pm	Am	pm	Am	pm	Am	pm	am	pm
A105	1.7± 0.4	1.1 ± 1.1	1.1 ± 1.0	0.90 ± 1.0	0.93± 1.2	0.67 ± 0.9	0.98±1.8	0.93± 0.6	0.92 ±1.2	1.3 ±2.0	1.0 ±1.2	0.42 ±0.8
A205	1.8 ± 0.4	0.61 ± 1.8	0.88 ± 0.6	0.81 ± 0.8	1.3 ± 0.8	0.57 ± 0.7	1.1 ±1.6	0.72 ±1.6	0.54 ±1.2	0.98±2.7	1.1 ±0.4	0.86 ± 1.3
A305	1.4± 1.1	1.1 ± 0.6	0.89 ± 1.0	0.63 ± 1.0	1.1 ± 0.8	0.53 ± 0.8	1.4 ±3.1	0.70 ±0.6	0.67±1.3	1.8 ±0.4	0.58 ±0.6	0.75 ±1.2
B105	1.0± 3.7	1.2 ± 1.1	0.99 ± 2.0	0.67 ± 0.8	0.73 ± 0.8	0.67 ± 0.2	1.3 ±3.6	0.70 ±1.4	0.40 ±0.5	1.7 ±4.1	0.79 ±0.6	0.88 ±0.4
B205	0.88± 1.1	0.74 ± 4.0	1.1 ± 1.6	0.65 ± 0.6	1.1 ± 1.4	0.65 ± 0.4	1.4 ±3.6	0.68 ±1.6	0.39 ±0.8	1.4 ±4.3	1.2 ±1.2	1.3 ±4.3
B305	1.2 ± 1.4	0.54 ± 4.4	1.5 ± 1.0	0.35 ± 0.4	1.2 ±2.1	0.82 ± 1.1	0.86 ±1.2	1.0 ±0.4	0.7±2.3	1.9 ±1.1	1.0 ±2.2	0.73 ±1.6
C105	1.1 ± 0.3	0.47 ± 1.0	0.66 ± 0.6	0.53 ± 0.6	0.77 ±0.9	1.0 ± 0.5	1.0 ±0.4	0.88± 0.2	0.9±1.8	0.98±3.5	0.65 ±0.6	0.53 ±0.5
C205	1.0 ± 2.3	0.79 ± 2.6	0.73 ± 0.5	0.53 ± 0.6	0.95 ± 0.8	0.48 ± 2.0	0.84 ±1.1	0.72± 1.1	0.53 ±1.1	1.5 ±3.5	0.29 ±0.1	0.96 ±0.9
C305	0.46 ± 0.3	1.1 ± 4.2	0.82 ± 0.4	0.46 ± 0.2	0.77±2.0	0.57 ± 0.4	0.48 ±0.8	0.60 ±1.0	0.78 ±0.2	2.0 ±0.8	0.61 ±2.0	0.84 ±1.8
D105	0.71 ± 0.5	0.89 ± 3.5	0.84 ± 1.1	0.35 ± 0.7	0.51 ± 0.4	0.73 ±1.4	0.77 ±1.4	0.80 ±1.2	0.98 ±0.3	2.7 ± 4.6	0.95 ±1.0	0.82 ±2.0
D205	1.2 ± 1.6	0.84 ±4.2	0.57 ± 0.8	0.42 ± 0.2	0.61 ± 1.0	0.67±1.2	0.86 ±1.2	0.80 ±1.6	1.0 ±1.0	1.8 ±0	1.1 ±0.4	0.80 ±0.2
D305	1.3 ± 2.4	0.82 ± 1.8	0.74 ± 0.9	0.38 ± 0.7	0.70 ± 1.6	0.90 ±0.8	1.0 ±2.3	0.60 ±0.2	0.34±0.8	1.6 ±0.2	1.5 ±3.5	1.1 ±0.7
E105	0.62 ±0.7	0.95 ± 4.2	0.96 ± 1.0	0.47 ± 0.3	1.2 ± 1.1	0.66 ±0.6	1.2 ±0.8	0.75±0.8	0.40±0.6	1.7 ±1.2	1.5 ±3.1	0.77 ±1.4
E205	0.49 ± 0.8	0.58 ± 1.1	0.39 ± 0.8	0.66 ± 0.6	0.64 ± 0.6	0.66 ±0.6	1.0 ±0.2	0.87 ±1.0	0.68 ±1.1	0.5±2.2	0.64 ±2.0	0.68 ±0.3
E305	0.78 ± 0.8	0.82 ± 3.5	0.56± 0.8	0.68 ± 1.6	0.61 ± 1.6	0.72 ±1.4	0.91 ±0.4	1.1±0.4	0.61± 0.8	1.1±2.3	0.79 ±1.6	1.7 ±2.6
F105	1.1 ± 0.4	1.0 ± 2.8	0.67 ± 0.6	0.73 ± 1.1	1.1 ± 2.6	0.61±0.2	0.74 ±1.4	0.6±2.2	1.0 ±1.8	2.1 ±0.5	0.80 ±2.0	1.2 ±0.5
F205	0.87 ± 1.0	0.58 ± 4.6	0.84 ± 0.5	0.36 ± 0.2	0.93±2.0	0.85 ± 1.1	1.7 ±1.8	0.6±2.1	1.7 ±0.2	1.2±1.8	1.3 ±2.2	1.2 ±0.8
F305	0.68 ± 0.2	0.61 ±2.8.	0.79 ± 0.8	0.52 ± 1.2	1.0 ± 2.3	0.80 ±1.2	1.3 ±4.2	0.82 ±1.1	1.2 ±1.1	1.4 ±2.3	0.84 ±1.8	0.81 ±1.0
C R	1.0 ± 1.4	0.89 ± 1.0	2.2 ± 1.0	0.63 ± 0.9	0.92±2.8	1.7 ±0.8	0.96 ±1.2	0.86 ±0.3	1.2 ±1.3	1.1 ±3.1	1.2 ±1.2	0.82± 0.8
Toilet	0.49 ± 0.8	0.73 ± 1.0	0.93 ± 1.1	0.64 ±0.4	0.54 ± 0.6	0.80 ±1.2	0.67 ±0.6	1.0 ±0.2	0.7±3.3	2.4 ±2.0	0.86 ±0.6	1.1 ±0.8
Bathroom	1.7 ± 4.6	0.64 ± 1.2	0.93 ± 1.1	0.63 ± 0.6	0.51 ± 0.3	1.1 ±1.2	0.92 ±1.1	0.72 ±1.4	0.91 ±1.2	1.1 ±0.4	0.60 ±1.0	1.1± 2.5
Corridor	0.82 ± 1.1	0.84 ± 2.3	0.77 ± 0.3	0.70 ± 1.2	0.84 ± 1.0	0.81±1.0	0.99 ±1.0	0.7±1.8	1.3± 1.1	1.6 ±2.3	0.92 ±1.4	1.2± 2.2

Key: CR: Common room,
A105 - F305: Residential rooms

Table 4: Coliform counts of indoor air environment in Hall 4 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3) in MacConkey Agar.

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm	Am	Pm
R1	0.74± 0.4	0.98±2.3	0.75± 0.8	0.51±0.3	0.72±0.5	0.96±0.2	1.1±1.6	0.65±1.2	0.59±0.3	1.0±2.8	0.86 ±0.3	1.5±2.6
R 2	0.99 ± 1.8.	0.46 ± 1.0	0.80± 1.2.	0.74±0.8	0.77±1.2	0.99±0.5	1.0±1.6	0.71±0.5	1.1±2.0	0.59±2.2	1.1±0.8	1.1 ±1.2
R 3	0.96± 1.0	0.58 ± 1.0	0.57± 0.6.	0.73±1.6	0.50±1.2	1.1±0.8	0.77±0.2	0.82±1.2	1.6±1.2	0.93 ±2.4	1.2±1.1	1.2 ±1.5
R 4	0.97±2.2	0.48 ± 1.1	0.86± 1.2	0.34±0.4	0.82 ±1.3	0.98±1.0	1.2±1.2	0.68±2.0	1.6±0.9	1.4±1.6	0.44 ±0.8	1.1 ±0.3
R 5	1.2 ± 1.4	0.51± 0.3	0.53± 1.1	0.31±0.6	0.64 ±0.8	0.96±0.7	0.97±0.8	0.91±0.6	1.4±4.6	0.81±0.5	0.61±0.8	1.2 ±2.2
R 6	1.2± 1.1	0.56± 0.6	0.71± 1.6	0.56±0.4	0.64±0.4	1.5 ±1.8	0.91±0.8	1.0±0.3	1.2±1.1	1.2±1.4	0.73±0.6	1.6 ±2.4
R 7	0.73± 1.1	0.42± 0.6	0.47± 0.4	0.79±1.4	0.54±0.7	1.1±3.5	0.77±1.4	1.3±1.1	1.4± 1.0	1.2 ±1.2	0.96±0.6	2.1 ±2.4
R 8	0.77± 1.2	0.91 ± 0.8	0.75± 0.8	0.64±0.8	0.60 ±1.0	0.64±2.2	0.98±2.3	0.97±2.3	1.4±1.6	1.9±2.2	0.53 ±0.2	2.3±3.1
R 9	0.88±2.0	0.45± 0.6	0.86±1.8	0.65±0.6	0.87±1.2	0.96±1.0	0.63±2.3	0.70±0.4	0.96±3.1	1.1±2.6	0.72±1.6	1.9 ±4.3
R10	0.51 ± 0.8	0.60± 0.8	0.61± 0.6	0.73±1.6	0.72±1.5	1.2⊥2.4	1.3⊥4.4	0.79⊥0.1	0.91⊥1.1	0.87⊥2.8	0.70⊥1.8	1.3 ⊥1.6
R 11	0.80± 0.6	0.57 ± 1.1	0.73± 1.1	0.74±1.4	1.3±3.2	0.98±2.3	0.54±0.6	0.99±0.5	0.78±1.4	0.95 ±0.8	0.97±0.2	2.0 ±2.6
R 12	0.86±2.000	0.78 ± 0.8	1.1 ± 0.3	0.60±0.5	1.2±2.0	0.61±1.0	0.90±1.0	0.84±1.2	0.78±1.1	1.2±1.1	1.2 ±0.1	1.1±1.8
R 13	0.77± 0.8	0.51± 1.0	1.2 ± 1.1	0.74±1.8	0.82 ±1.2	0.92 ±1.2	0.99±0.5	0.44±0.8	1.1 ±0.6	0.78±0.8	0.78 ±2.2	1.7±3.5
R 14	0.41± 0.8.	0.39 ± 0.8	0.67±2.2	0.54±0.6	0.61±1.0	1.1±0.1	0.88±1.0	0.92±1.0	1.2 ±0.4	0.36±0.3	0.39±0.8	1.3 ±2.0
R 15	0.60± 1.0	0.56± 1.1	0.77± 0.8	0.75±0.8	1.3±2.6	0.79±1.1	1.2±1.2	0.81±0.6	1.1±0.6	0.74±1.4	0.72±0.4	0.98 ±1.0
R 16	0.89± 0.6	0.39± 0.6	0.78±2.000	0.84±1.1	0.99 ±0.8	0.66±0.6	1.4±4.6	1.1±0.5	0.99±0.2	0.48±0.5	0.63±1.8	0.97±0.3
R 17	1.1± 1.4	0.92± 0.6	1.2 ± 1.2	0.48±1.1	1.0 ±1.3	0.72±1.1	1.0±4.7	0.71±2.0	0.80 ±1.2	1.2±3.1	1.0±1.0	1.6±4.1
R 18	1.1 ± 1.7.	0.71±2.000	0.63± 1.4	0.61±1.0	1.0±1.8	1.1 ±0.2	1.2±1.2	0.90±0.6	1.4±1.8	1.6±0.2	0.84 ±0.6	1.4 ±1.6
C R	0.86± 1.0	0.38± 0.6	0.47± 0.3	0.73±1.0	0.95 ±1.0	0.91±1.0	1.2±1.2	0.81±0.2	1.9±2.6	1.2±1.1	1.0 ±0.6	2.1 ±1.4
Toilet	0.60± 1.0	0.60± 0.8	1.1 ±1.6	0.71±1.2	1.0 ±0.2	0.96±0.2	2.3±1.4	1.2±1.8	1.4 ±1.6	0.99 ±0.4	0.96 ± 2.3	1.8±3.2
Bathroom	0.87± 1.2	0.63± 0.8	0.75± 1.2	0.64±1.2	0.64 ±0.4	1.1±0.3	1.6±2.8	0.58 ±0.4	0.87±1.0	0.96±1.0	1.0±2.4	1.2 ±1.6
Corridor	0.93± 0.8	0.63 ± 0.8	0.72± 0.4	0.77±0.6	0.80±0.9	1.1 ±0.3	1.1±2.0	0.76± 0.5	1.2±1.1	1.5±3.1	0.66±0.6	2.9±2.0

CR: Common Room,
R1 - R18: Residential Rooms

Table 5: Fungal counts of indoor air environment in Hall 3 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3 ± S.D) in Potato Dextrose Agar (PDA).

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	Am	Pm	Am	Pm	Am	pm	am	pm	am	pm	am	pm
A105	1.2 ± 1.1	1.1 ± 1.1	0.84 ± 0.4	0.66 ±1.2	0.66 ±0.6	0.64 ± 1.2	0.84 ±1.6	0.75 ±1.6	1.2 ±2.3	1 ±2.3	0.65 ±0.4	0.82 ±0.5
A205	1.1 ± 1.8	0.67 ± 0.4	0.57 ± 0.4	0.59 ±0.3	0.59 ± 1.0	0.75 ± 0.1	0.85 ± 1.0	1.0 ± 0.3	1.0 ± 1.4	0.9 ± 2.2	0.59 ± 1.2	0.72 ± 0.4
A305	1.4± 0.6	0.71 ± 2.0	0.82 ± 0.8	0.61± 1.0	0.75 ± 1.2	0.78 ± 1.1	0.74 ±0.4	0.67 ±1.4	0.72 ±2.0	0.63±2.0	0.66 ±1.1	0.58 ± 1.1
B105	0.92 ± 1.1	0.58 ± 0.4	0.99 ± 0.4	0.42 ±1.2	0.79 ± 1.4	0.51 ± 1.0	0.74 ±0.6	0.84±0.6	0.70 ±2.0	0.97±2.0	0.58 ±0.3	1.0 ±0.4
B205	0.98 ±4.0	1.1 ± 0.4	0.84 ± 1.1	0.78± 0.2	0.60± 0.4	0.68 ± 0.6	1.2 ±1.1	0.87 ±1.1	0.61 ±0.1	1.1 ±0.4	0.79 ±0.1	0.65 ± 0.4
B305	0.61 ±4.4	0.84 ± 1.1	0.66 ± 1.2	0.72±0.5	0.93 ±1.5	0.72 ± 0.4	0.77 ±1.4	0.88 ±1.0	0.95 ±1.0	0.99±2.2	0.97 ±2.4	0.60±1.1
C105	1.2 ± 1.0	0.66 ± 0.8	0.45 ± 0.1	0.50± 0.4	0.54 ± 0.6	0.96 ± 0.2	1.0 ±1.2	0.98 ±0.5	0.88±1.2	0.60 ±1.0	1.1 ±0.4	0.92 ±1.1
C205	1.1 ± 2.6	0.56 ± 0.6	0.57 ± 0.4	0.82± 0.6	0.52 ± 0.4	0.73 ± 1.6	0.98±2.7	0.88±1.0	0.52 ±1.8	0.41 ±0.6	0.98±0.3	0.88 ± 0.4
C305	0.87 ± 4.2	0.79 ± 0.1	0.87 ± 0.8	0.72 ±0.6	0.80±1.2	0.60 ± 0.8	0.40 ±0.4	0.61 ±1.0	0.52 ±1.1	0.38 ±0.2	0.86 ±0.8	0.88 ±1.1
D105	0.65 ± 3.5	0.95 ± 0.6	0.93 ± 0.8	0.82 ±1.1	0.75 ± 1.3	0.60 ± 0.2	0.64 ±0.4	0.99± 0.4	0.53 ±0.6	0.48 ±0.6	0.84 ±2.6	0.52 ± 1.2
D205	0.67 ± 4.1	0.96 ± 1.2	0.73 ± 0.2	0.66 ±0.6	0.72 ± 1.6	0.67 ±0.4	0.92 ±0.8	0.99±2.6	0.56 ±0.3	1.2 ±0.6	1.2 ±0.4	0.60 ±1.6
D305	0.88 ± 1.8	0.45 ± 0.6	0.60 ± 0.2	0.66 ±0.6	0.41 ± 0.3	0.66 ±0.4	0.77 ±1.4	0.60 ±0.8	0.74±1.1	0.47 ±0.1	1.6 ±0.8	0.66 ±1.0
E105	0.98 ± 4.2	0.86 ± 1.2	0.95 ± 1.2	0.53± 0.8	0.48 ± 0.4	0.73 ± 0.9	0.95 ± 0.8	0.90 ± 0.6	0.87 ± 1.0	0.81 ± 3.3	0.95 ±4.2	0.70 ± 0.4
E205	0.92 ± 1.1	0.67 ± 1.8	0.99 ± 0.4	0.60± 0.2	0.82 ± 1.1	0.92 ±1.0	1.4 ±0.4	0.90 ±0.6	0.56 ±1.1	1.0 ±0.6	0.33±0.3	0.90 ±0.6
E305	0.63 ±3.5	1.0 ± 0.2	0.77 ± 1.4	0.66 ±0.6	0.77 ± 1.4	0.74 ±0.4	1.1 ±0.7	0.75 ±0.3	0.32 ±1.1	0.85 ±0.4	0.54 ±1.1	0.80 ±0.9
F105	0.93 ±2.7	1.2 ± 0.8	0.89± 0.6	0.68 ±0.8	0.61 ±1.0	0.70 ± 1.8	0.88 ± 0.6	0.64 ± 0.4	0.35 ± 0.4	1.1 ± 0.4	0.33 ± 1.0	1.4 ± 0.8
F205	1.2 ± 4.9	0.72 ± 2.0	0.86 ± 1.1	0.39±0.8	0.93±2.7	0.73±1.8	0.90 ±0.6	0.64 ±0.4	0.65 ±0.8	0.80±2.0	0.41 ±0.6	1.1 ±0.4
F305	1.2 ± 2.8	0.61 ± 1.0	0.85 ± 1.0	0.59 ±0.8	0.66 ± 0.6	0.86 ±0.8	1.1 ±0.2	0.71 ±0.4	1.3 ±1.0	0.99±2.6	0.86±1.6	0.99 ±1.4
C R	1.3 ± 1.0	0.65 ± 0.8	0.70 ± 1.1	0.74 ±1.1	0.64 ± 0.2	0.97 ± 0.4	0.71 ± 2.2	0.74 ± 0.5	0.63 ± 1.6	0.88 ± 2.8	0.68 ± 1.4	1.1 ± 0.2
Toilet	0.96 ±1.0	0.66 ± 0.6	0.84 ± 1.4	0.80 ±0.2	0.68 ± 0.8	0.78±0.8	0.98 ±0.2	0.60 ±0.2	0.66±2.6	0.79 ±0.1	1.1 ±2.3	0.96 ±0.8
Bathroom	0.93 ± 1.2	0.48 ± 0.8	0.78 ± 1.1	0.57 ±0.8	0.90±2.4	0.78 ±1.1	0.67 ±0.6	0.81 ±1.2	1.0 ±2.2	0.92 ±0.4	0.88 ±1.2	0.63±1.6
Corridor	1.1 ± 2.3	0.67 ± 0.2	0.82 ± 1.1	0.64 ±0.5	0.64 ± 0.4	0.65 ± 0.4	0.51 ± 0.8	0.85 ± 1.2	0.79 ± 1.1	1.2 ± 0.3	0.73 ± 2.0	1.0 ± 0.6

Key
A105 - F305: Sleeping rooms
CR: Common room

Table 6: Fungal counts of indoor air environment in Hall 4 male student hostel between September 2011 and February 2012 ($\times 10^3$ cfu/m^3) grown in Potato Dextrose Agar (PDA).

Sampled Areas	Sept. 2011		Oct.2011		Nov. 2011		Dec.2011		Jan.2012		Feb.2012	
	Am	Pm	Am	Pm	Am	pm	am	Pm	Am	Pm	Am	Pm
R1	0.66 ± 0.6	0.73 ± 0.4	0.63±0.6	0.54±1.0	0.46±0.8	0.95±0.6	0.68±0.3	0.82 ±1.6	1.2±1.2	1.1±0.7	0.73±0.8	0.82±0.8
R 2	0.86±1.1	0.78 ±1.2	0.58±1.0	0.49 ± 0.8	0.59±0.8	1.1±0.8	0.93±0.8	0.65±0.6	1.5±3.5	0.78 ±1.6	0.51± 0.4	0.84± 1.4
R 3	0.53± 0.6	0.74± 0.6	0.47±0.6	0.47±0.8	0.68±0.2	0.88±1.2	0.60±2.3	0.57 ±0.4	1.1±0.4	0.91 ±1.1	0.54± 1.2	0.45± 0.8
R 4	0.68 ± 0.6	0.66 ± 0.2	0.56±1.0	0.59± 1.2	0.88±0.8	0.74±0.4	0.42±0.4	0.56 ±1.0	1.5 ±2.8	0.80± 1.2	0.91 ±2.0	1.0 ±1.2
R 5	0.60 ± 0.8	0.58±1.0	0.29±0.4	0.87±1.2	0.90 ±1.1	0.68±1.2	0.66 ±0.6	0.5±1.0	0.81±0.2	1.1 ±1.6	0.31 ±0.6	0.47 ±1.1
R 6	0.57 ±0.4	0.96 ±0.4	0.85± 0.4	0.71 ±1.4	0.84±0.8	0.74±1.6	0.84±1.1	0.93±0.8	0.99±3.1	0.92 ±0.4	0.54 ±1.6	0.74± 7
R 7	0.68±1.0	0.63±1.0	0.61±0.6	0.64±0.8	0.81±1.1	0.66±0.6	0.90±0.1	0.63±1.6	1.2±0.3	1.1 ±0.2	0.59 ±2.0	0.27 ±0.3
R 8	0.65 ± 0.8	0.92 ± 0.4	0.66±0.6.	0.88±1.0	0.93±0.8	1.1 ±0.8	0.96±1.0	0.39±0.2	1.4±1.2	0.92±2.8	0.70 ±1.2	0.60 ±0.8
R 9	0.71 ± 1.2	0.84±1.8	0.60±0.4	0.93±1.4	1.0±0.4	0.77±1.8	0.79±0.1	0.61±0.4	1.0±1.2	0.42 ±1.1	0.66 ±1.4	0.67 ±0.6
R10	0.88 ± 1.1	0.59+ 1.0	0.72± 0.4	0.52 ±0.2	0.78±0.8	0.79 ±0.1	1.2±1.2	0.66±1.0	1.2±0.8	0.95 ±1.0	0.36 ±0.2	1.1 ±0.6
R 11	0.73 ± 1.4	0.80+ 0.6	0.97±0.4	0.47 ±0.6	0.84 ±1.0	0.91±0.3	0.59±2.2	0.64±0.8	1.0±0.6	0.86 ±0.8	0.67±1.1	0.39 ±0.8
R 12	0.66 ±0.5	0.45± 0.4	0.65±0.4	0.86 ±1.2	0.78 ±1.2	0.84 ±1.8	0.61±1.2	0.85±1.4	0.73 ±0.4	0.95 ±1.0	0.66 ±0.6	0.45 ±0.6
R 13	0.96±0.8	0.92 ± 0.8	0.40±0.6	0.57±0.4	0.80 ±0.8	0.79 ±1.1	0.63±2.0	0.34±0.4	0.88±2.3	0.71±2.0	1.9 ±0.6	0.54 ±0.6
R 14	0.74 ± 1.1	0.91± 1.1	0.66±0.6.	0.81±1.2	0.79±0.1	0.91 ±2.0	0.78±1.4	0.95±0.8	1.3±4.0	1.1 ±0.2	0.56 ±0.6	0.53 ±0.4
R 15	0.66± 0.6	0.69±0.8	0.77±1.6	0.64±0.8	0.75 ±1.0	0.64± 0.8	0.91±0.6	0.78 ±0.3	0.97±0.8	1.2 ±0.8	0.66±0.6	0.84 ±0.4
R 16	0.66± 0.8	0.82± 1.1	0.96±1.0	0.63±2.3	0.87± 1.2	0.74±0.4	0.86±0.8	0.80 ±0.2	1.2±1.8	0.90 ±0.8	0.86 ±0.6	0.92 ±0.8
R 17	0.73±1.6	0.64 ± 0.4	0.78±1.4	0.66±0.6	0.60±0.8	0.92 ±1.1	0.86 ±0.2	0.64±2.0	0.99 ±2.0	1.1±1.6	0.78±0.6	0.79 ±1.4
R 18	0.81± 0.8	0.44±0.6	0.66±0.6	0.88±1.4	0.63±0.4	0.67±1.8	1.1±0.2	1.2±1.2	0.79±0.1	6.8 ±2.0	0.90 ±2.0	1.2±0.2
C R	0.38± 0.2	0.57 ±1.0	0.68±1.6	0.68±1.2	0.95 ±0.6	0.46 ±0.2	1.3± 0.8	1.4±1.1	1.4±1.1	1.2±1.4	0.56±1.0	1.0 ±0.5
Toilet	0.65± 1.4	0.67±0.6	0.52±0.6	0.60 ±1.1	0.90 ±0.8	0.66 ±0.6	0.81 ±3.1	1.0±0.4	1.2±2.0	2.0±1.2	0.53 ±0.4	0.91± 1.0
Bathroom	0.56± 0.4	0.87 ±1.0	0.36± 0.4	0.72±2.0	0.86 ±1.1	1.1 ±0.2	0.39±0.4	0.78±0.2	1.5±1.2	0.79±1.1	0.66 ±0.6	0.96 ±1.0
Corridor	0.80± 1.1	0.57±1.4	0.97±0.8	0.78±2.0	0.96±0.8	1.1±1.6	0.54±0.6	0.53±1.0	0.93±0.8	0.48±0.6	0.47±0.4	0.75 ±1.0

Key: CR: Common Room,
R1 - R18: Residential Room

Table 7: Frequency of occurrence (percentage) and distribution of airborne bacterial isolates indoor air environments in Hall 3 and Hall 4

Isolate	**Period of sampling months**											
	September, 2011		**October, 2011**		**November, 2011**		**December, 2011**		**January, 2012**		**February, 2012**	
	H3	**H4**	**H3**	**H4**	**H3**	**H4**	**H3**	**H4**	**H3**	**H4**	**H3**	**H4**
Bacillus spp.	24	19	37	22	14	26	17	28	41	29	35	14
Enterobacter aerogenes	47	55	55	61	56	64	52	68	56	53	56	46
Escherichia coli	40	31	44	34	37	38	38	37	47	34	31	34
Klebsiella spp.	30	39	34	37	33	42	29	43	31	42	29	39
Micrococcus spp.	12	30	15	30	18	26	16	33	20	37	19	30
Staphylococcus epidermidis	19	30	25	31	16	24	15	23	14	20	20	19
Serratia marcescens	46	47	35	49	39	48	40	50	34	49	33	51

Key: H 3 – Hall 3

H 4 – Hall

Table 8: Frequency of occurrence (percentage) and distribution of airborne fungal isolates of indoor air environments in Hall 3 and Hall 4

Isolate	Period of sampling months											
	September, 2011		October, 2011		November, 2011		December, 2011		January, 2012		February, 2012	
	H3	H4	H3	H4	H3	H4	H3	H4	H3	H4	H3	H4
Aspergillus niger	77	82	57	89	92	91	79	96	94	89	86	79
Aspergillus versicolor	63	74	38	79	44	94	68	85	71	86	74	98
Candida spp.	83	Nil	71	9	58	20	76	22	77	Nil	69	Nil
Mucor mucedo	7	42	Nil	48	36	37	47	52	23	45	Nil	45
Penicillium chrysogenum	86	56	94	66	91	58	89	45	85	74	92	77
Penicillium spp.	93	77	85	63	82	91	93	84	88	57	89	71
Rhizopus spp.	12	20	25	Nil	21	Nil	26	8	33	20	27	12
Rhodotorula spp.	24	36	20	25	Nil	33	41	38	33	7	Nil	34
Saccharomyces cerevisiae	20	5	71	10	58	12	76	Nil	77	Nil	69	23

Key: H 3 – Hall 3

H 4 – Hall 4

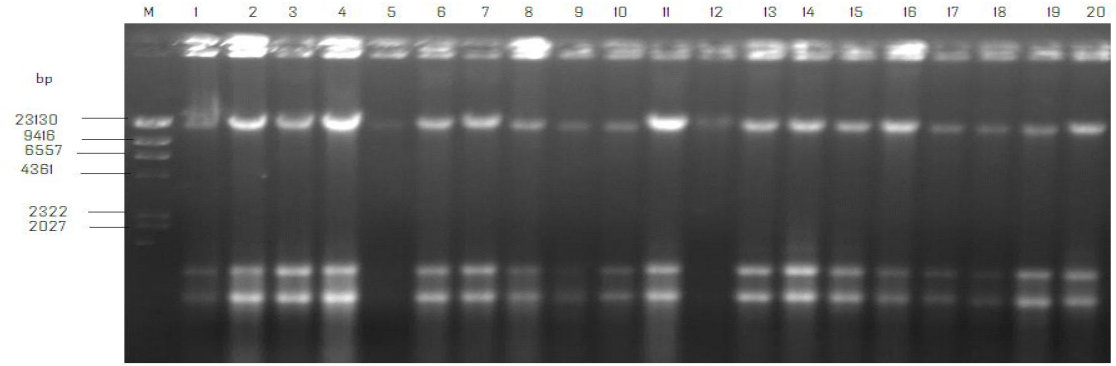

Fig 1: Agarose gel electrophoresis of plasmids recovered from the bacterial isolates. Lane M = 10 kb DNA ladder marker; lanes 1 -16, 19 and 20 = Bacterial isolates screened; Lanes 17 & 18 = Negative control [Loading buffer (2 uL) + TE buffer (8 uL)

KEY
2,11 and 4: *Enterobacter aerogenes,* 3, 6 and 7: *Micrococcus* sp.*,* 13 and 14: *Staphylococcus epidermidis*
1,5, 10 and 9: *Escherichia coli,* 8, 16, 19 and 15: *Klebsiella* sp. *,* 12: *Bacillus* sp.*,* 20: *Serratia marcescens*

Table 9: Antibiogram profile of the airborne bacterial isolates present in the indoor air environments sampled

Bacterial isolate	CAZ	OFX	AUG	AZM	CXM	CIP	LVX	E	OB	CRO
Escherichia coli	R	S	S	R	R	S	I	S	R	R
Klebsiella spp.	R	R	R	S	R	R	R	R	R	S
Bacillus spp.	S	S	S	R	R	S	I	S	R	R
Enterobacter aerogenes	S	R	R	R	R	R	R	R	R	I
Serratia marcescens	R	R	S	R	R	R	R	S	R	S
Micrococcus spp.	R	S	R	I	R	S	S	R	R	R
Staphylococcus epidermidis	S	R	R	S	R	R	R	R	R	S

KEY: S : Sensitive, I: Intermediate, R: Resistant

CRO- Rocephin, LVX-Levofloxacin, CAZ- Fortum, E- Erythromycin, OFX- Ofloxacin, OB- Cloxacillin
AUG-Augumentin, AZM-Azithromycin, CXM-Cefuroxine, CIP-Ciprofloxacin

Table 10. Temperature and relative humidity values recorded for Hall 3 male student hostel during the period of study (September, 2011 - February, 2012)

	Morning		Afternoon		IEE permissible limits	
Sampled areas	Temperature ^{0}C	Rel. Humidity%	Temperature ^{0}C	Rel. Humidity%	Temperature ^{0}C	Rel Humidity %
A105	*30±2.4	68±2.6	29±3.1	69±3.1	22.5-25.5 ℃	< 70 %
A205	28±1.6	68±1.4	30±1.8	70±1.5	22.5-25.5 ℃	< 70 %
A305	28±2.2	68±2.2	30±2.5	70±2.5	22.5-25.5 ℃	< 70 %
B105	29±1.5	69±1.5	30±3.1	70±2.4	22.5-25.5 ℃	< 70 %
B205	29±0.4	69±0.4	31±1.8	71±1.8	22.5-25.5 ℃	< 70 %
B305	28±1.2	66±1.5	31±2	71±2	22.5-25.5 ℃	< 70 %
C105	29±1.9	69±1.9	31±1	70±1	22.5-25.5 ℃	< 70 %
C205	28±1.9	68±1.9	31±1.9	71±1.9	22.5-25.5 ℃	< 70 %
C305	29±1.3	69±1.5	30±1.9	70±1.7	22.5-25.5 ℃	< 70 %
D105	29±1.6	69±1.3	31±1.9	71±1.7	22.5-25.5 ℃	< 70 %
D205	29±1.5	69±1.5	31±1.7	71±1.4	22.5-25.5 ℃	< 70 %
D305	29±1.2	69±1.2	31±1.5	71±1.3	22.5-25.5 ℃	< 70 %
E105	29±1.5	69±1.5	31±2.8	70±2.5	22.5-25.5 ℃	< 70 %
E205	28±1	69±1.1	28±2.6	68±3	22.5-25.5 ℃	< 70 %
E305	27±0.9	67±0.9	29±1.6	69±1.6	22.5-25.5 ℃	< 70 %
F105	28±1.7	68±1.7	29±1	69±1	22.5-25.5 ℃	< 70 %
F205	29±1.5	69±1.4	30±1.2	70±1.2	22.5-25.5 ℃	< 70 %
F305	27±0.8	67±0.8	29±1.6	69±1.5	22.5-25.5 ℃	< 70 %
Common room	28±1.7	68±1.7	29±2.5	69±2.5	22.5-25.5 ℃	< 70 %
Toilet	29±1.9	69±1.6	30±2.4	70±2.4	22.5-25.5 ℃	< 70 %
Bathroom	28±2.2	68±2.2	30±2.1	70±1.9	22.5-25.5 ℃	< 70 %
Corridor	28±1.9	68±1.9	29±2.2	69±2.2	22.5-25.5 ℃	< 70 %

***values = mean ± S. D, IEE: Institute of Environmental Epidemiology**

Table 11. Temperature and relative humidity values recorded for Hall 4 male student hostel during the study period (September, 2011 - February, 2012)

Sampled areas	Morning		Afternoon		IEE permissible limits	
	Temperature ^{0}C	Rel. Humidity%	Temperature ^{0}C	Rel. Humidity%	Temperature ^{0}C	Rel. Humidity %
R1	*28±1.6	68±1.3	30±2.3	70±2.3	22.5-25.5 ℃	< 70 %
R2	30±2.3	70±2.3	31±2.9	71±2.9	22.5-25.5 ℃	< 70 %
R3	30±3	69±1.2	32±1.6	71±1.9	22.5-25.5 ℃	< 70 %
R4	30±1.9	69±1.8	31±1.5	71±1.5	22.5-25.5 ℃	< 70 %
R5	30±1.6	70±1.4	31±1.6	71±1.6	22.5-25.5 ℃	< 70 %
R6	29±1.4	69±1.6	31±1.7	71±1.7	22.5-25.5 ℃	< 70 %
R7	29±1.9	69±1.9	31±1	70±1	22.5-25.5 ℃	< 70 %
R8	31±1.2	68±1.1	31±1.9	71±1.9	22.5-25.5 ℃	< 70 %
R9	29±1.3	69±1.4	30±1.9	70±1.7	22.5-25.5 ℃	< 70 %
R10	29±0.6	68±1.3	31±1.9	70±1.6	22.5-25.5 ℃	< 70 %
R11	29±1	69±1.4	31±1.7	71±1.1	22.5-25.5 ℃	< 70 %
R12	30±1.3	68±1.3	30±1.6	71±1.7	22.5-25.5 ℃	< 70 %
R13	30±1	69±1	30±0.8	70±2.3	22.5-25.5 ℃	< 70 %
R14	27±1	69±1.1	29±2.0	69±1	22.5-25.5 ℃	< 70 %
R15	28±0.5	68±1.3	28±1.3	68±1	22.5-25.5 ℃	< 70 %
R16	29±1.6	68±1.6	30±2.8	70±2.5	22.5-25.5 ℃	< 70 %
R17	29±1.5	69±1.6	31±2.3	71±2.3	22.5-25.5 ℃	< 70 %
R18	30±1	68±1.2	30±2.5	71±2.1	22.5-25.5 ℃	< 70 %
Common room	28±1.7	68±1.7	30±2.3	69±2.3	22.5-25.5 ℃	< 70 %
Toilet	30±1	69±1.3	29±2.1	70±2	22.5-25.5 ℃	< 70 %
Bathroom	29±1	69±1	31±1.8	71±1.8	22.5-25.5 ℃	< 70 %
Corridor	28±1.4	68±1.2	31±1.5	70±2	22.5-25.5 ℃	< 70 %

***values = mean ± S. D, IEE: Institute of Environmental Epidemiology**

Discussion

Human beings need a regular supply of food, water and an essentially continuous supply of air. The requirements for air and water are relatively constant; 10 - 20m^3 and 1 - 2 litres per day respectively (17). That all people should have free access to air and water of acceptable quality is a fundamental human right (17). The highest airborne heterotrophic bacterial count for the respective residential rooms 8.6 ± 7.8 ×10^3 cfu/m^3 was recorded in room E205 of Hall 3 male student hostel in the morning sampling period (Table 1). This high bacterial load coincided with an observed maximal anthropogenic activity within this room during agar plate exposure as residents were preparing and leaving the room to attend lectures. This trend could also be a reflection of the number of residents occupying the room and the size of the room. Yassin and Almouqatea (2010) stated that there was a direct relationship between the magnitude of indoor airborne bacterial counts, the size of the occupied space or room and the number of residents occupying the space. They further stated that the higher the number of residents confined to a small space, the higher the build-up of airborne microbes shed by the human body. The positive influence of human activity on the indoor airborne flora of the sampled areas within the hostels has also been collaborated by Stryjakowska - Sekulska *et al.* (2007). They reported that people occupying or visiting enclosed spaces play a dominating role in the creation of indoor air microbiological environments. Karwowska, (2003) and Fleischer *et al.* (2006) had also reported a strong relationship between occupant density, human activity and microorganismôs concentration in the indoor air. Stryjakowska - Sekulska *et al.* (2007) stated that the human body as well as clothing is a natural place for growing microorganisms. Soto *et al.* (2009) also reported that most bacteria present in air are often part of the normal human microflora.

The highest airborne heterotrophic bacterial count in the afternoon sampling time for Hall 3 (Table 1) and Hall 4 (Table 2) were recorded in sleeping rooms D205; 2.7 ± 2.3 ×10^3 cfu/m^3 and R17; 2.4 ± 0.8 ×10^3 cfu/m^3 respectively . This trend suggests that aside from human activities within these sampled areas, other factors such as accumulated dust might play a significant role in affecting the numbers and diversity of the airborne bacterial load. Burge (1995) stated that house dust is a primary reservoir and a potential source of indoor bioaerosols. There were fluctuations in the morning and afternoon mean fungal counts of the indoor air environments in the respective hostels; 0.32 ± 1.1 × 10^3 cfu/m^3 to 1.4 ± 0.4 × 10^3 cfu/m^3 and 0.38 ± 0.2 × 10^3 cfu/m^3 to 1.4 ± 0.8 × 10^3 cfu/m^3 in Hall 3 and 0.2 ± 0.4 × 10^3 cfu/m^3 to 1.9 ± 0.6 × 10^3 cfu/m^3 and 0.27 ± 0.3 × 10^3 cfu/m^3 to 6.8 ± 2.0 × 10^3 cfu/m^3 in Hall 4 (Table 5 and 6). The impact of anthropogenic activity on indoor airborne fungi has been

known to be lesser than its effect on airborne bacterial load (22). Calderon *et al.* (1997), Nayak *et al.* (1998), Kasprzyk *et al.,* (2004, Kasprzyk and Worek, (2006) reported that the content of fungal spores of every taxon in air is characterized by a specific seasonal and diurnal cycle. Among other things, these cycles depend on climate and weather conditions (28; 29) on the accessibility of fresh substrates for the development of the fungus, circadian cycle of light and darkness, and other environmental hardly definable factors (30; 31). For some of the sampling months, the airborne bacterial and coliform counts were higher than the airborne fungal load (Tables 1 - 6). This observation is in tandem with a report by Soto *et al*., (2009) which stated that generally bacterial concentration usually outnumbers fungal load in indoor environments. There was no significant difference ($P > 0.05$) between the morning and afternoon airborne microbial counts obtained in Hall 3 male student hostel in the months of November, 2011 and February, 2012. The differences in the airborne bacterial counts obtained in Hall 3 and 4 male student hostels in the months of September, 2011, October, 2011 and January, 2012 were significant ($P < 0.05$).

Amongst the airborne bacterial isolates, *Enterobacter aerogenes* was the most dominant in both hostels (Table 7). This could be a reflection of the extent of human activities within the sampled areas of these hostels during the sampling period, as *E. aerogenes* is a commensal present on the skin and within the intestinal tract of humans (Farmer, 1995). This trend contrasted with reports by Stryjakowska - Sekulska *et al*. (2007) and Soto *et al*. (2009) who reported the dominance of gram positive isolates such as *Micrococcus* sp., *Bacillus* spp. and *Staphylococcus* spp. amongst other bacterial isolates identified in their respective studies. The observed pre-dominance of *Aspergillus niger, Aspergillus versicolor*, *Penicillium* spp. and *P. chrysogenum* were not surprising as these molds have been described as ñindoor moldsò (19). This observation was at variance with a report by Soto *et al*., (2009). They reported that amongst indoor fungal isolates recovered from the Faculty of Biology at the University of Murcia, Spain *Cladosporium* spp. and *Alternaria* spp. were the most prevalent.

The discovery of airborne *Enterobacter aerogenes* and *Klebsiella* spp. which harbored plasmids (Figure 1) and displayed resistance to majority of the antibiotics utilized in the antibiotic sensitivity assay (Table 9) is very significant. This phenomenon would suggest the ubiquitous distribution of plasmid bearing antibiotic resistant bacterial isolates in the indoor air environments in these hostels. Although members of the *Enterobacteriaceae* are known to exhibit intrinsic or chromosomal resistance patterns against certain antibiotics such as cephalothin, ampicillin and nitrofurantoin (32), the resistance exhibited by *E. aerogenes* and *Klebsiella* spp. against erythromycin, azithromycin and augmentin was plasmid mediated. This type of resistance also known as intrinsic resistance (32), has been attributed to the selective pressure of antibiotic usage by individuals. The plasmid nonbearing *Escherichia coli* and *Bacillus* spp. exhibited susceptibility against more antibiotics in contrast to the other plasmid borne isolates (Figure 1 and Table 9).

There were minimal variations in the mean temperature and relative humidity values obtained for the male student hostels (Table 10 and 11). Comparatively, the morning indoor air temperature readings obtained in Hall 3 were lower than readings recorded in Hall 4 (Table 10 and 11). The observed structural differences for both male hostels could be responsible for the slight differences in the indoor air temperature readings. The increased indoor air temperature values observed in both hostels in the afternoon could be a reflection of the influences of the surrounding outdoor climatic effects on the indoor air temperature of these residential hostels. Also the extent of ventilation within these sampled areas might also be a significant factor affecting the mean indoor temperatures of these locations. Bornehag *et al.* (2001) reported that increasing local ambient temperatures implied higher human exposure to heat during hot seasons in hot equatorial regions of the world. This event created very severe heat stress and health risks for people who are not able to afford both the cost of air conditioning and other cooling systems nor the cost of energy required to run them.

The average indoor air temperature and relative humidity values obtained in the sampled areas in both residential hostels were above the stipulated guidelines prescribed by the IEE (1996) (Table 10 and 11). This trend is worrisome as Arundel *et al*. (1986) reported that a combination of high humidity and high temperatures can result in the reduction of the rate of evaporative cooling of the body causing considerable discomfort or leading to heat stroke, exhaustion, and possibly death. The high relative humidity observed for the sampled areas within these hostels could however discourage the survival of several airborne viral pathogens. Arundel *et al*. (1986) stated that measles, influenza, herpesvirus varicellae, and rubella viruses survive longer during exposure to relative humidity below 50%.

Conclusion

The examined indoor air in the areas within the respective hostels contained a host of viable microflora. Anthropogenic activities positively affected the numbers and diversity of the indoor microbial population of these hostels. The physical attributes (temperature and relative humidity) of the indoor air environment in the respective hostels was poor when compared to existing standards drafted by the Institute of Environmental Epidemiology (33) for indoor air. This would infer that the overall thermal comfort within these hostels is very poor. Temperature and relative humidity are important parameters that can be used in ascertaining the thermal comfort of residential locations. In light of this trend it is suggested that the appropriate department in charge of day to day management of the hostels should look at available viable options aimed at improving the poor thermal comfort status within these hostels. Some of these options are: increasing the amount of ventilation within these rooms and eliminating the widespread phenomena of ñsquattingò within these hostels. Squatting invariably leads to overcrowding and overcrowding reduces the thermal comfort in these hostels. The microbiological quality of indoor air is formed by two main factors, microbiological composition of outdoor air and indoor air microbial sources. It is recommended that the microbial flora of the surrounding outdoor air of these hostels should be investigated.

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