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MICROBIOLOGICAL QUALITY OF INDOOR AIR IN SOME SELECTED BUILDINGS AT MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY, YOLA

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Abstract
The study aimed at investigating the quality of indoor air quality in some selected buildings at Modibbo Adama University of Technology Yola, Nigeria. Air samples were taken twice a week, morning and afternoon using settle plate method. In all the tested buildings a multiple growth of bacterial colonies and fungal spores were observed in the afternoons when compared to morning. The predominant bacteria isolated from the air samples were *Staphylococcus aureus* with frequency of 87.4%, *Micrococcus* spp. with frequency of 80.6%, *Klebsiella pneumonia* spp. with frequency of 47.0%, *Actinomyces* spp. with frequency 43.7% and *Serratia mercenscens* with frequency of 23.5%, while the isolated fungi included *Cladosporium* spp. with frequency of 66.2%, *Aspergillus* spp. with frequency of 57.6%, *Penicillium* spp. with frequency of 51.8% and *Alternaria* spp. with the frequency of 31.7%. The result of the determination of bacterial andfungal count showed that the highest count was found in the afternoon with461 CFU/m^3 and 418 CFU/m^3 while the lowest count in the morning with94 CFU/$m^3$and 83 CFU/$m^3$for both bacteria and fungi respectively. Among these microbes the presence of opportunistic pathogens that are involved in the establishment of sick building syndrome and saprophytic microflora which is generally associated to human skin and mucosa was detected. Possible causes of indoor air quality problem should be analyzed in order to retain healthy indoor environments. The level of air contamination can be reduced by the application of some chemical and physical agents such as ultraviolet radiation and the use of air filters which has great potential value for reducing the microbial flora of the air.
Keywords: Bacteria, Bioaerosols, Fungi, Indoor air, Microbiological quality.

INTRODUCTION

Indoor environments are fundamental environmental factors capable of impacting health. Air quality of indoor environments is one of the main factors affecting health, wellbeing and productivity of people who inhale 14m^3 of the air every day (Brochu *et al.*, 2006), and spend between 80-95% of their lives indoors (Dacarro *et al.*, 2003).

The air inhaled by people in indoor environment is abundantly populated with microorganisms such as bacteria, fungi and moulds which form so called bioaerosols (Yassin *et al.*, 2010). Bioaerosols are always present in our environment and pose no problems in most cases when the air quantities are kept within reasonable limits. However, some bioaerosols, when breathed in, can cause diseases including pneumonia, asthma, rhinitis (e.g., cold, hay fever), and respiratory infection (U.S National Institution of Health, 2014). A review made by WHO on the number of epidemiological studies showed that, there is sufficient evidence for an association between indoor dampness-related factors and a wide range of effects on respiratory health, including asthma development, asthma exacerbation, respiratory infections, cough, wheeze and dyspnea (WHO, 2010).

Many common indoor air quality problems are associated with improperly operated and maintained heating, ventilating and air-conditioning (HVAC) systems, overcrowding, moisture incursion and dampness, presence of outside air pollutants, and the presence of internally generated contaminants such as use of cleaning and disinfecting supplies and aerosol products, off-gassing from materials in the building, and use of mechanical equipment. People, organic dust, various materials stored in the buildings remains the major sources of biological contamination of indoor air (Amengialue *et al.*, 2017)). Dust serve as a vehicle in transporting microorganisms from outside environment to the rooms by sweeping, walking and wind. Many different species may dominate the indoor environment depending on amount of viscosity, temperature, lighting, and food present in that environment (Dumala and Dudzinska, 2013).

Sneezing has been found to be one of the strongest way of producing millions of droplet into the environment with the maximum falling to the ground and smaller amount evaporate and remain suspended as nuclei (Awosika *et. al.*, 2012). Improper temperature and relative humidity conditions can also present problems, especially concerning comfort (Dumala and Dudzinska, 2013; U.S National Institution of Health, 2014). Thus microbiological air quality remain a salient issue that must be considered when indoor workplaces are designed to provide a safe environment. This study gives an insight on the current concentration of microorganisms and describes bacterial and fungal loads for some selected sites of Modibbo Adama University of Technology, Yola.

MATERIALS AND METHODS

Study Area

The sampling location used for the study were some selected building in Modibbo Adama University of technology, Yola, Adamawa state. The selected buildings include lecture theatres (1, 2 and 5), laboratories (Biochemistry, Chemistry and Microbiology) and offices (A, B and C).

Sampling Procedure

Air sample was collected in the school environment using settle plate method in 8.5cm diameter petri dishes containing culture media following the procedure described by Borrego *et al.*, 2010. Each plate was exposed to air for a period of 20 minutes. Sampling was done by collecting samples in the morning at 8:00am and afternoon at 4:00 pm twice a week, for a period of two months from February to March. A total of 288 samples were collected from lecture theatres (1, 2 and 5), laboratories (Biochemistry, Chemistry and Microbiology) and offices (A, B and C). The plates containing nutrient agar (NA) and potato dextrose agar (PDA) were used for the isolation of bacterial and fungal isolates respectively. An antifungal agent (Griseofulvin) was incorporated into the nutrient agar medium for the inhibition of fungi while antibiotic (Chloramphenicol) into potato dextrose agar medium for the inhibition of bacterial growth. The bacterial culture plates were incubated at a temperature of 37^0C for 48hours in an incubator while the fungal culture plates were left on the laboratory working bench at room temperature (20-28^0C) for 5-7 days.

Microbiological Examination

After incubation, the total number of bacteria, yeast and moulds in the air samples from different sites collected were enumerated. The total number of colony forming unit (CFU/m^3) was calculated using the equation described by Borrego *et al*. (2010).

$N = 5a \times 10^4 (bt)^{-1}$, Where N=microbial CFU/$m^3$ of indoor air; a=number of colonies per Petri dish; b=dish surface (cm^2); t=exposure time (min).

Identification of bacteria and fungi was done using the standard proceduredescribed by Cheesbrough, (2000). The bacterial cultures were identified by using microscopic (using staining techniques) and biochemical characterizations. The fungal cultures were identified on the basis of microscopic (using Lactophenol cotton blue staining and wet mounting techniques) and macroscopic characteristics (Zafar *et al*., 2007).

RESULTS AND DISCUSSION

The microbiological quality of indoor air in some buildings in Modibbo Adama University of technology, Yola was determined with 288 samples. Out of which 168 bacterial isolates and 144 fungal isolates were identified.

The bacterial isolates were suspected to include *Actinomycetes* spp., *Micrococcus* spp., *Staphylococcus aureus, Klebsiella pneumoniae* spp. and *Serratia mercensces* (Table 1). The most isolated bacteria are Gram positive cocci belonging to saprophytic microflora, generally associated to human skin and mucosa, thereby suggesting that the main bacterial contamination suspended in the indoor air are derived from human presence. *Staphylococcus aureus* was found to be the most abundant bacterial isolate in all the building with a percentage frequency of occurrence of 87.4 %while *Serratia marcescens* was found to be the least in abundances with a frequency of 23.5 % (Table 1).Thus, this might be attributed to the assertion by Kavita and Jyothi (2013)that *Serratia marcescens* were generally an opportunistic pathogen thatdoes not infect healthy human being, whereas the immunocompromised people can be frequently colonized or infected. The fungal isolates includes; *Cladosporium* spp., *Alternaria* spp.,*Penicillium* spp.and *Aspergillus niger* which are recognized as opportunistic pathogens for humans and often associated with clinical manifestations of allergy, rhinitis, asthma and conjunctivitis. Also, these microorganisms are considered as potential candidates involved in the establishment of sick building syndromes (Jones, 1999 and Schwab *et al.*, 2004).

Table 1: Frequency of occurrence of bacterial isolates

S/N	Isolates	Number of isolates	Frequency (%)
1	*Staphlococcus aureus*	52	87.4
2	*Micrococcus* spp.	48	80.6
3	*Klebsiella pneumoniae* spp.	28	47.0
4	*Actinomyces* spp.	26	43.7
5	*Serratia marcescens*	14	23.5
	Total	168	

The most frequent fungal isolates were *Cladosporium* spp. And *Aspergillus niger* with a percentage frequency of 66.2 % and 57.6 % respectively (Table 2) while the least occurred fungal isolate was found to be *Alternaria* spp. with percentage frequency of 31.7 % (Table 2). These airborne microfloras were similar to that obtained by Amengialue *et al*. (2017) who reported the isolation of fungal isolate, that include*: Penicillium* spp.*, Aspergillus* spp.*, Cladosporium*spp.and*Mucor*spp.in university of Benin. The study is also in correlation with that of Stryjakowska-Sekulska *et al*.(2007) who detected some strains from genera: *Fusarium, Penicillium* and *Rhizopus* in university rooms.

Table 2: Frequency of occurrence of fungal isolates

S/N	Isolates	Number of isolates	Frequency (%)
1	*Cladosporium* spp	46	66.2
2	*Aspergillus* spp	40	57.6
3	*Pencillium* spp	36	51.8
4	*Alternaria* spp	22	31.7
	Total	144	

The concentrations of bacteria and fungi measured in all the buildings were significantly different to each other (P <0.005). Similar observations by other studies are in agreement with this result (Soto *et al.*, 2009 and Samuel and Abayneh, 2014).

The result of the determination of bacterial count showed that the highest bacterial count for both morning and afternoon was observed in Lecture theatre 4 with 286 CFU/$m^3$and 461 CFU/m^3 respectively, while the lowest was observed in Office A with 94 CFU/$m^3$and 150CFU/m^3 for both morning and afternoon respectively (Figure 1).For the fungal count, the highest number of fungi was recorded in the afternoon with 418CFU/$m^3$and 337 CFU/m^3in the morning at Lecture theatre 4 while the least was recorded at the Office C with 83CFU/m^3 in the morning and 121 CFU/m^3in the afternoon (Figure 2).When compared with the guidelines of National Ambient Air Quality Standard (EPA, 2016), both the highest bacterial and the fungal count are above the recommended values (> 400 CFU/m^3). The highest count of bacterial and fungal colonies was always found to be during the afternoon. These findings were in conformity with reports by Sryjakowska *et a*l., (2007) who recorded an elevated amount in bacterial load in lecture halls at the start of the session. It means that all the buildings attended by many students will be exposed to high risk of microbial contamination.

The nature and type of activity that holds in the respective sampling locations contributed to the characteristics difference in the microbial load during this study. As shown from the results, lecture theatres shows highest concentration of microorganism compared to other buildings. Thus, this could be due to the high density of students occupying the building. In addition, these students come from different areas. Thus, they might be carrying along with the spores of different microorganisms, which could be released from their body surfaces as they continuously move or as a result of continues disturbances in the lecture theatre. A correlation between bacteria and the number of persons in a room has been previously stated by (Sryjakowska *et a*l., 2007; Gouse *et al*., 2015). Lowest number of airborne bacteria and fungi were recorded in office rooms when compared with lecture theaters because of few number of persons working in office rooms and regular cleaning of the floors properly with disinfectants frequently. The number of bacteria and fungi is more in laboratories than that of the office rooms due to handling of microbiological specimens during practical hours' inspite of using disinfection procedures.

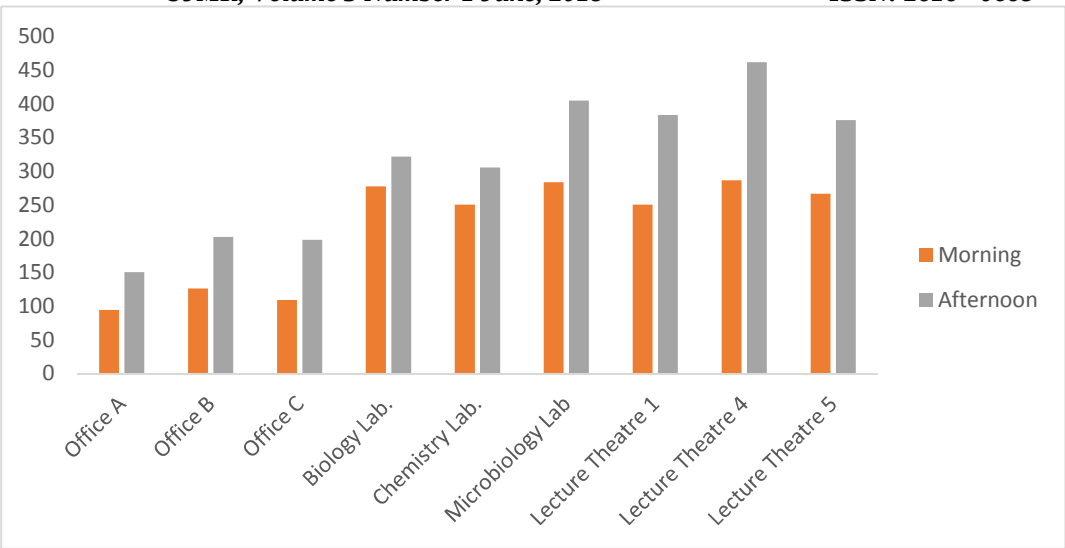

Figure 1: Total Bacterial Count of the selected Buildings indicating bacterial count of each site in Colony Forming Unit per metre cube (CFU/m^3)

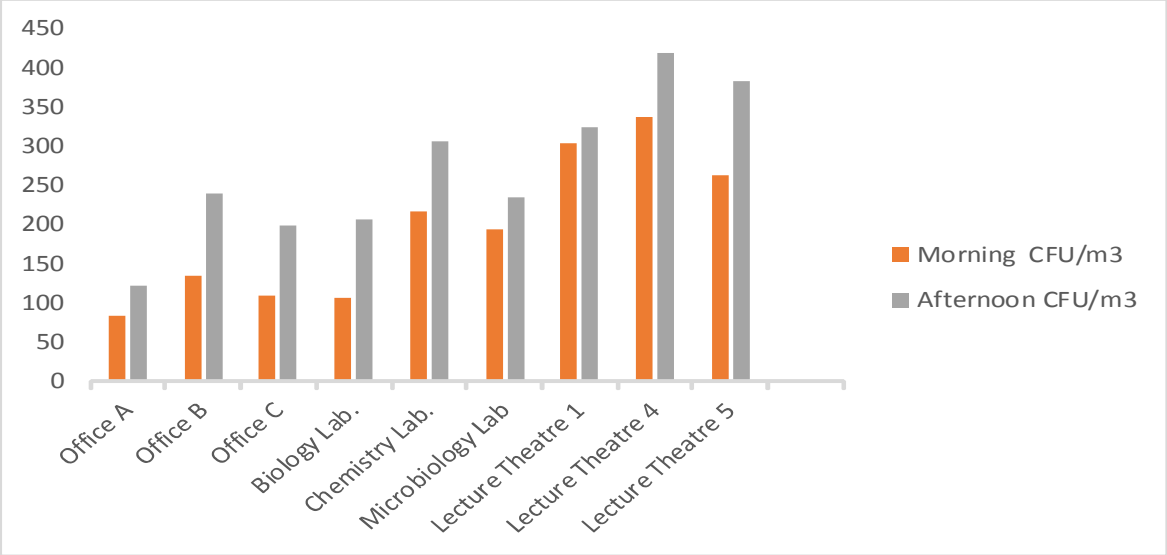

Figure 2: Total Fungal Count of the selected Buildings indicating fungal count of each site in Colony Forming Unit per metre cube (CFU/m^3).

Overcrowding has to be avoided and good ventilation systems has to be designed in order to develop the quality of indoor air in the university building (Geller *et al.*, 2007). If the building has more moisture due to cracks in the wall, fungal spores can easily dispersed through the droplets and it can grow and proliferate extensively.

CONCLUSION

The indoor air of most of the selected buildings falls in the range 80 to 470 CFU/m^3 and were considered moderately or highly contaminated with bacteria and fungi according to National Ambient Air Quality Standards (EPA, 2016).Some of these isolates are known to be potential etiological agents of sick building syndromes. Thus, proper control measures need to be consider to prevent environmental factors which favor the growth and multiplication of different bacteria and fungi in indoor environment of the university building in order to protect the health of students, staff and workers.

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