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# Microbial Assessment of Indoor Air Quality of Laboratory Sections in Obong University, Obong Ntak, Nigeria

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## ABSTRACT

**Background:** Poor indoor air quality constitutes a significant health problem in schools, mostly in the laboratory sections due to a high number of students per laboratory vis-a-vis space confinement, insufficient outside air supply, poor construction and maintenance of laboratory buildings. Aim: This study was carried out to assess the air quality and identify airborne bacteria and fungi in selected sections of Obong University Laboratory.

**Materials and Methods:** Institutional based study employing passive air sampling, settle plate or gravitational sampling method to collect airborne bacteria and fungi was conducted in 3 selected laboratory sections of the University. Culture, isolation, colony count/air quality assessment and identification of airborne bacteria and fungi were done using standard methods.

**Results:** The mean bacterial load was 111.75 CFU/$m^3$ in the morning and 125.25 CFU/$m^3$ in the afternoon. The highest and lowest bacterial loads were recorded at the Laboratory Animal Room (LAR) to be 165 CFU/$m^3$ and 201 CFU/$m^3$ in the morning and afternoon, respectively. The total fungal load was 100 CFU/$m^3$ in the morning and 170 CFU/$m^3$ in the afternoon with the mean estimate of 25 CFU/$m^3$ in the morning and 42.5 CFU/$m^3$ in the afternoon. The highest fungal load was equally estimated in the LAR at a percentage rate of 55% and 54.12% in the morning and afternoon, respectively. The results of the indoor air quality assessment of the different laboratory sections revealed a very low (<50 CFU/$m^3$) to low (50-100 CFU/$m^3$) degree of both fungal and bacterial air pollution within the sampling time. A total of 3 bacterial and 5 fungal species were isolated as follows: *Staphylococcus aureus* 16(61.5%), *coagulase negative Staphylococcus species* (*CoNS*) 7 (27%) and *Bacillus species* 3 (11.5%); *Aspergillus flavus* 7 (25%), *Aspergillus niger* 8 (28.5%), *Penicillium chrysogenum* 4 (14.3%), *Rhizopus spp*. 5 (17.9%) and *Fusarium spp*. 4 (14.3%). The levels of indoor airborne bacteria and fungi as revealed in this study were found to be within the acceptable and permissible limits of microbial load ≤500 CFU/$m^3$.

**Conclusion:** Attention should be given to control those human, animal and environmental factors which favour the proliferation of bacteria and fungi in the indoor environment of school laboratories to safeguard the health of students, lecturers and laboratory personnel in the University.

***Key Words:*** Microbial Quality, Indoor Air, Laboratory, Colony, Pollution

## INTRODUCTION

Clean air is a basic prerequisite for a healthy life.[1] In the laboratory environment where students, in a confined space, spend most of their time during the day to learn and carry out practical, a safe and healthy laboratory is needed for them to thrive, learn and succeed.[2,3] Studies have shown that most people spend 80-95% of their time in indoor environment breathing an average of 10-14$m^3$ of air per day.[4,5]

Bacteria and fungi are found almost in every environment including surviving in extreme environmental conditions such as heat, pressure, radiation, salinity, darkness and cold.[6] The components of air includes: oxygen, nitrogen, carbon dioxide, trace elements, inorganic particles and particles of biological origin.[7] The indoor air quality has been an issue of public health concern by scientific community because of its negative impact upon health especially as people spend more time indoors than outdoors. The quality of air inside homes, offices, schools, classrooms, dormitories, laboratories, or other private and public buildings is an essential determinant of healthy life and people's well-being.[1]

Microorganisms are the primary sources of indoor air contamination due to the fact that enclosed spaces can confine aerosols and allow them to build up to infectious levels.[8] Microbial damage in indoor/outdoor areas is caused most frequently by molds and bacteria. They have a very important role in the biochemical cycle, as their task consists of disintegrating organic mass to reusable metabolites. Spores of molds and bacteria may become airborne and are therefore ubiquitous and can enter indoors by means of passive ventilation.[9] Bacteria and fungi are also emitted by sources such as laboratory animals, flower pots and waste baskets. The normal flora is not always harmful. Okafor and Opuene[10] showed that growth conditions like excessive humidity and high-water content of building materials are limiting factors for microbial growth.

Microorganisms in the atmosphere were revealed by the experiment of Spallanzani in the middle of the 18$^{th}$ century and Pasteur at the end of the 19$^{th}$ century.[11,12] Microbes according to Pasteur are normally found in the atmosphere within 300-10000 feet above the land. Fungal spores such as *Alternaria*, *Cladosporium*, *Penicillium*, and *Aspergillus* have been reported to be found above 4000 feet from the land of both polar and non-polar air masses. According to Jaffal et al.[8] microorganisms such as bacteria, fungi, viruses and other spores are almost always present in the air. The quality of indoor air is not readily controlled and can place laboratory technicians at risk.

Indoor air pollution constitutes a significant health risk to people. Indoor air quality may be influenced by bacteria, pollen grains, smoke, humidity, chemical substances, and gases released by anthropogenic activity which adversely affects human's health.[13] A number of studies underscore the significant risks of global warming on human health as a result of increasing levels of air pollution. The last decades have seen a significant increase in the concentrations of pollens and pollutants in the air with concomitant increase in the number of people presenting with allergic symptoms such as allergic rhinitis, conjunctivitis, and asthma.[14]

In 2016, about 3.8 million deaths were attributed to indoor air pollution globally. Out of this, 90% of air pollution-related deaths occurred in low- and middle-income countries, such as Asia and Africa, as well as in low- and middle-income countries of the Eastern Mediterranean region, Europe, and Americas.[15]

In terms of air pollutants, bioaerosols contribute about 5–34% of indoor air pollution.[16,3] Indoor air quality problems in schools and laboratory sections may be even more serious than in other categories of buildings, due to higher occupant density, poor sanitation of classrooms, and insufficient outside air supply, aggravated by frequent poor construction and maintenance of school and laboratory buildings.[17]

Poor indoor air quality can also affect scholarly performance and attendance, especially among students with underlying health condition or compromised immune system which may be vulnerable to health risks from exposure to the environmental hazard.[18,17] Greater number of microorganisms which can be harmful to human health is deposited in the laboratory due to one or more factors which includes human normal flora and normal human activities. The sources of laboratory air micro flora could be due to factors such as staff natural flora, visitors, students and materials

in the laboratory. Human activities like coughing, sneezing, talking and yawning may also contribute to the source of laboratory microflora and infection.[19] Therefore, the purpose of this study was to assess the microbial quality of indoor air in laboratory sections of Obong University to increase awareness and provide references for better understanding about indoor air quality problems in the University Laboratory.

## MATERIALS AND METHODS

### Study area:

The study was carried out between December 2019 to March 2020 and September 2020 to December 2020 before and after the nationwide lockdown due to Covid-19 pandemic, respectively at the Microbiology Laboratory of Obong University, located at Etim Ekpo Local Government Area. Etim Ekpo, created from the former Abak division is one of the Annang-speaking areas with GPS coordinates 5°1'N 7°37'E and time zone UTC +1 (WAT). According to the National Population Commission of Nigeria (web) and the National Bureau of Statistics (Web), the population statistics of Etim Ekpo is 148, 800 (2016 population census). It is a town situated in Akwa Ibom State, South-South geopolitical zone of Nigeria.

### Description of sampling sites:

In the present study, three sections of Obong University Laboratory were selected as sampling sites for the collection of airborne bacteria and fungi. These sections are: The Laboratory Store (LS), the Laboratory Animal Room (LAR) and the Main Laboratory Section (MLS) where practicals and lectures are carried out. These sites differ basically in terms of population density, type and intensity of anthropogenic activities. All sampling was carried out at day time at temperature of 22– 25$^{o}$C.

### Sampling method and cultivation of airborne bacteria and fungi:

The passive sampling based on settle plate method otherwise called gravitational sedimentation sampling was used to collect airborne bacteria and fungi. Airborne bacterial samples were collected in Blood Agar (BA) and Nutrient Agar (NA) plates to which an antifungal agent Griseovulfin, had been added to inhibit the growth of fungi, while airborne fungal samples were collected in Sabouraud Dextrose Agar (SDA) and Potato Dextrose Agar (PDA) plates to which Chloramphenicol had been added as a bacterial growth inhibitor, which were previously prepared aseptically. Two standard Petri dishes each with 9cm diameter (63.585 cm$^2$areas) were exposed in the three laboratory sections by placing them at the height of 18cm above the ground level in various corners for sample duration of 1 h to determine the bacterial and fungal load. With respect to environmental variation, sampling was done in the morning (6:00am before students enter the laboratory) and afternoon (5:00pm after students left the laboratory). After exposure, the Petri dishes were sealed with masking tapes and labeled accordingly. The plates were incubated aerobically at 37$^{o}$C for 24 to 48 h in case of bacteria and at 25$^{o}$C for 4-7 days in case of fungi.

### Colony count and isolation of airborne bacteria and fungi:

After incubation, developed colonies in bacterial and fungal plates were enumerated and expressed as colony forming units per cubic meter (CFUm$^{-3}$). To determine the microbial concentration in terms of bacterial load, the following equation was used.[20]

$$N = \frac{a \times 10000}{bt \times 0.2}$$

Where N = microbial CFU/m$^3$ of indoor (laboratory) air; a = number of colonies per petri dish; b = dish surface area in cm$^2$; t = exposure time.

Morphology of each colony was noted with respect to shape, pigmentation, elevation, and texture. Morphologically different colonies were sub cultured unto new media to obtain pure cultures. Pure stock cultures of isolated bacteria were stored in 30% glycerol at -20$^{o}$C, while pure cultures of fungi were

stored as tube slant at 4°C until further use.[21]

**Identification of isolated airborne bacteria:**

Identification of airborne bacterial isolates were done microscopically by Gram staining and biochemically using the following biochemical tests: Catalase test, Coagulase test, Citrate test, Triple sugar iron (TSI) test and Motility-indole-ornithine (MIO) test. Biochemical test results were evaluated using the Bergey's Manual of Systemic Bacteriology.[22]

**Identification of Isolated Airborne Fungi:**

Identification of fungal isolates was based on cultural and microscopic characteristics. Observations were evaluated and compared to what is documented in the literature.[23]

## RESULTS

Table 1 shows the total bacterial load and percentage bacterial count in the indoor laboratory sections of Obong University, estimated with the use of the settle plate method. The highest and lowest bacterial load was estimated in the LAR (165 CFU/$m^3$) and MLS (132 CFU/$m^3$) in the morning; and LAR (201 CFU/$m^3$) and LS (148 CFU/$m^3$) in the afternoon, respectively. The percentage bacterial count was highest in the LAR (40.12%) in the afternoon and lowest in the MLS (29.53%) in the morning.

**Table 1: Indoor colony counts for bacteria in different laboratory sections of Obong University using the settle plate method**

| Location | No. of plates | Total count | Mean count | % count |
|---|---|---|---|---|
| Morning Bacterial Load | | | | |
| LS | 4 | 150 | 37.5 | 33.56 |
| LAR | 4 | 165 | 41.25 | 36.91 |
| MLS | 4 | 132 | 33 | 29.53 |
| Total | 16 | 447 | 111.75 | 100 |
| Afternoon Bacterial Load | | | | |
| LS | 4 | 148 | 37 | 29.54 |
| LAR | 4 | 201 | 50.25 | 40.12 |
| MLS | 4 | 152 | 38 | 30.34 |
| Total | 16 | 501 | 125.25 | 100 |

(LS = Laboratory Store; LAR = Laboratory Animal Room; MLS = Main Laboratory Section)

Table 2 shows the total fungal load and percentage fungal count in the three laboratory sections of Obong University, estimated using the settle plate method. The highest and lowest fungal load was estimated in the LAR (55CFU/$m^3$) and MLS (20 CFU/$m^3$) in the morning; and LAR (92 CFU/$m^3$) and MLS (35 CFU/$m^3$) in the afternoon, respectively. The percentage fungal count was highest in LAR (55%) and lowest in MLS (20%) in the morning.

**Table 2: Indoor colony counts for fungi in different laboratory sections of Obong University using the settle plate method**

| **Location** | **No. of plates** | **Total count** | **Mean count** | **% count** |
|---|---|---|---|---|
| Morning Fungal Load | | | | |
| LS | 4 | 25 | 6.25 | 25 |
| LAR | 4 | 55 | 13.75 | 55 |
| MLS | 4 | 20 | 5 | 20 |
| Total | 16 | 100 | 25 | 100 |
| Afternoon Fungal Load | | | | |
| LS | 4 | 43 | 10.75 | 25.29 |
| LAR | 4 | 92 | 23 | 54.12 |
| MLS | 4 | 35 | 8.75 | 20.59 |
| Total | 16 | 170 | 42.5 | 100 |

(LS = Laboratory Store; LAR = Laboratory Animal Room; MLS = Main Laboratory Section)

The degree of indoor air quality of the different sections of Obong University laboratory in terms of bacterial load is shown in table 3. The results indicate a low to very low degree of air pollution within an hour period in the afternoon and morning.

**Table 3: Indoor air quality assessment of the different laboratory sections of Obong University in terms of bacterial load**

| **Sampling time** | **6.00-7.00am** | | | | | **5.00-6.00pm** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Range of values (CFU/m$^3$) | <50 | 50-100 | 100-500 | 500-2000 | >2000 | <50 | 50-100 | 100-500 | 500-2000 | >2000 |
| Degree of air pollution | v. low | Low | Interm. | High | v. high | v. low | Low | Interm. | high | v. high |
| LS | √ | - | - | - | - | √ | - | - | - | - |
| LAR | √ | - | - | - | - | - | √ | - | - | - |
| MLS | √ | - | - | - | - | √ | - | - | - | - |

(≤500CFU/m$^3$is the permissible standard; (√) in the range value; (-) not in the range; v. low = very low; interm. = intermediate; v. high = very high; LS = laboratory store; LAR = laboratory animal room; MLS = main laboratory section).

Table 4 below shows the degree of indoor air quality of the different sections of Obong University laboratory in terms of fungal load. The results indicate a very low degree of concentration of fungi in the indoor laboratories of Obong University within the sampling periods.

**Table 4: Indoor air quality assessment of the different laboratory sections of Obong University in terms of fungal load**

| **Sampling time** | **6.00-7.00am** | | | | | **5.00-6.00pm** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Range of values (CFU/m$^3$) | <50 | 50-100 | 100-500 | 500-2000 | >2000 | <50 | 50-100 | 100-500 | 500-2000 | >2000 |
| Degree of air pollution | v. low | Low | Interm. | High | v. high | v. low | Low | Interm. | high | v. high |
| LS | √ | - | - | - | - | √ | - | - | - | - |
| LAR | √ | - | - | - | - | √ | - | - | - | - |
| MLS | √ | - | - | - | - | √ | - | - | - | - |

(≤500CFU/m$^3$is the permissible standard; (√) in the range value; (-) not in the range; v. low = very low; interm. = intermediate; v. high = very high; LS = laboratory store; LAR = laboratory animal room; MLS = main laboratory section)

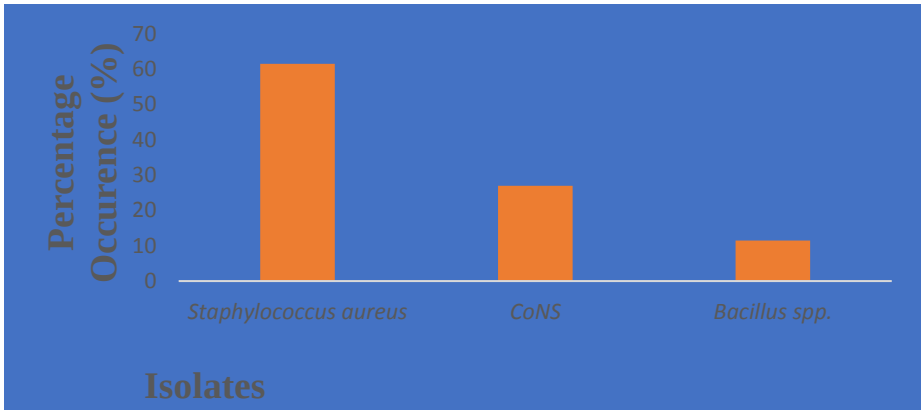


**Figure 1: Percentage frequency occurrence of airborne bacterial isolates in the study area**

Figure 1 above shows the percentage frequency occurrence of airborne bacteria isolated from the study area using settle plate method. The result indicates that *Staphylococcus aureus* were the most isolated bacteria with percentage occurrence of 61.5%, followed by *coagulase negative staphylococcus species* (*CoNS* = 27%) with the least being *Bacillus spp*. (11.5%).

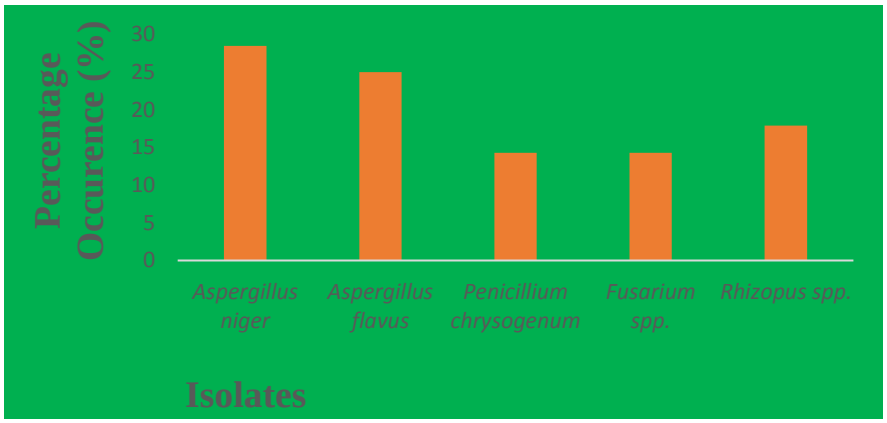


**Figure 2: Frequency of occurrence of airborne fungal isolates in the study area.**

The percentage frequency of occurrence of fungal isolates in the study area using agar plate method is as shown in figure 2. The result shows *Aspergillus niger* (28.5%) and *Aspergillus flavus* (25%) as the dominant fungal isolates which were closely followed by *Rhizopus spp.* (17.9%) while both *Fusarium species* and *Penicillium chrysogenum* occur at the same percentage frequency of 14.3%.

**Table 5: Morphological, cultural and biochemical characteristics of isolated airborne bacteria in Obong University laboratories by settle plate method**

| | M.I.O Test | | | | | TSI Test | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isolate | Colony morphology | Cells shape | Hemolysis | Gram reaction | Catalase | Coagulase | citrate | motility | Indole | ornithine | glucose | sucrose | Lactose | gas | $H_2S$ | Suspected bacteria |
| 1. | Spherical, raised and golden yellow colonies. | Cocci in irregular clusters | + | + | + | + | + | - | - | + | + | + | + | - | - | *Staphylococcus aureus* |
| 2. | Spherical, smooth, raised and glistering colonies. | Cocci in irregular clusters | - | + | + | - | - | - | - | + | + | + | + | + | + | *Coagulase negative staphylococcus species* |
| 3. | Large, grey-white and granular colonies | Straight rods in pairs and chains | + | + | + | N R | + | + | - | + | + | + | - | - | - | *Bacillus species* |

(NR = not required; M.I.O Test = Motility-indole-ornithine Test; TSI Test = Triple sugar iron test).

The morphological, cultural and biochemical characteristics of indoor airborne bacteria isolated in Obong University laboratories using the settle plate method is shown in table 5. Results obtained revealed the presence of *Staphylococcus aureus*, coagulase negative staphylococcus species and *Bacillus species* as suspected indoor airborne bacteria in the laboratory environment.

**Table 6: Morphological and microscopic characteristics of isolated airborne fungi in Obong University laboratories by agar plate method**

| Isolates | Morphology on SDA | Morphology on PDA | Microscopic characteristics | Suspected fungi |
|---|---|---|---|---|
| A | Colonies exhibited white mycelia growth with dark spots which later increases with time. The margin of the fungi was whitish while the colonies were yellowish. | Black colonies with yellow edges. Colony surfaces were powdery with emerging erect and transparent structures which later become black. | Hyphae are septate. Conidiophores formed terminate in a swollen vesicle. | *Aspergillus niger* |
| B | Colonies were yellow-brown and powdery with whitish mycelium at the edges. | Colonies were yellow-green with whitish powdery edge. | Vesicles are globule and phialides are produced directly from the vesicle surface. Conidiophores terminate in swollen vesicles. | *Aspergillus flavus* |
| C | Colonies are whitish-green with margins within | Greenish colonies with white edges and powdery surface. Growth rate appeared slow. | Presence of hyaline and septate hyphae. Conidiophores produce a brush-like structure. | *Penicillium chrysogenum* |
| D | White colonies resembling cotton but with less aerial mycelia growth as compared to that on PDA. | Snow white colonies at the initial stage which later turned pink with time. Showed aerial mycelia growth. | Hyphae are septate. Produces rod-like and slightly bent macroconidia. | *Fusarium species* |
| E | Fluffy and whitish hyphal that turns brown after three days. Aerial mycelia growth is observed with the reverse plate showing yellow. | Colonies are white to milky with black spores all over and cottony mycelia. | Floccose and saclike sporangia that contain sporangiospores and are connected to one another by septate hyphae. | *Rhizopus species* |

(PDA = Potato dextrose agar; SDA = Sabouraud dextrose agar)

Table 6 above shows the morphological and microscopic characteristics of isolated airborne fungi in three laboratory sections of Obong University using agar plate method. Four different fungal genera were isolated. Fungal isolates included *Aspergillus niger*, *Aspergillus flavus*, Peni*cillium chrysogenum*, *Fusarium spp.* and *Rhizopus spp.*

## DISCUSSION

The quality of air in an ambient environment is influenced by the level of concentration of airborne microorganisms. Studies have revealed the predominance of fungi and bacteria in indoor environment at any given time. Poor indoor air quality constitutes a significant health problem in schools, mostly in the laboratory sections due to a high number of students per laboratory in relation to space confinement, insufficient outside air supply, poor construction and maintenance of laboratory buildings.[1,2]

In this study, experiments were conducted to identify airborne bacteria and fungi and also to assess the level of these microorganisms in three selected laboratory sections of Obong University. The results of bacterial and fungal load in the present study indicated that there were significant differences in the number of isolated bacteria and fungi in relation to the laboratory sections investigated. In this study, the bacterial load of indoor laboratory environments of Obong University was found in the range between 447 CFU/$m^3$ in the morning and 501 CFU/$m^3$ in the afternoon with a mean bacterial load of 111.75 CFU/$m^3$ and 125.25 CFU/$m^3$ in the morning and afternoon, respectively. The highest bacterial load was estimated in the Laboratory Animal Room (LAR) to be 165 CFU/$m^3$ and 201 CFU/$m^3$ in the morning and afternoon, respectively. The findings of this study were lower than that obtained from a similar study conducted among 51 selected classrooms in public primary schools in Gondar city[24] including that conducted in Poland[25] and Malaysia.[26]

The results also showed the total fungal load of 100 CFU/$m^3$ in the morning and 170 CFU/$m^3$ in the afternoon with the mean fungal estimate of 25 CFU/$m^3$ and 42.5 CFU/$m^3$ in the morning and afternoon, respectively. The highest fungal load was equally estimated in the LAR at a percentage rate of 55% and 54.12% in the morning and afternoon, respectively. The levels of bacteria and fungi have been reported to be related to the population density, animal and human activities as well as traffic at any given environment. This is true when the level of bacterial and fungal estimates is compared with the different laboratory sections of Obong University. As indicated in many reports, humans and animals are the main generators of indoor bioaerosols.[27,28] Different human activities such as talking, coughing, sneezing and shedding of skin cells contribute in generating or increasing the levels of bioaerosols in the indoor environment. However, sneezing is considered one of the most vigorous mechanisms of generating airborne microbes, which has been estimated to be up to two million of droplets per sneeze.[29] Additionally, both humans and animals can release small skin fragments from the body containing different bacterial and fungal species. Studies have shown that, humans walking alone can generate up to 5,000 bacteria per minute to the surrounding air.[30]

In this study, indoor air quality assessment of the different laboratory sections of Obong University was also carried out to ascertain the degree of indoor air pollution. The results obtained revealed a very low (<50 CFU/$m^3$) to low (50-100 CFU/$m^3$) degree of both fungal and bacterial air pollution within the sampling time. Several studies have been conducted to assess the level of concentration of indoor aerosols and their correlation with pollution level and health safety. At present, there are no generally accepted threshold limit values concerning concentrations of microbial aerosols of indoor environments. However, the obtained values could only be compared with the values recommended by various authors and institutions. In a study conducted by a WHO expert group on

assessment of health risks of biological agents in indoor environments, it was suggested that total microbial concentration should not exceed 1000 CFU/$m^3$,[31] whereas other scholars considered that 750 CFU/$m^3$ should be the limit for bacteria.[32] According to the sanitary standards of the European Commission for non-industrial premises, the permissible limits of bacterial load were ≤500 CFU/$m^3$. The results obtained from this study gives airborne microbial concentration range of 50-100 CFU/$m^3$, which is within the acceptable limits of microbial load as stated by the European Commission.[33]

A total of 26 bacterial and 28 fungal isolates were obtained in this study. This consists of 3 bacterial and 5 fungal species. The isolated bacteria and their percentage frequency of occurrence were: *Staphylococcus aureus* 16 (61.5%), *coagulase negative Staphylococcus species* (*CoNS*) 7 (27%) and *Bacillus species* 3 (11.5%). These isolated bacterial species were all Gram positive with one, the *Bacillus spp*. being also an endospore former. The genus *Bacillus* is endospore-forming whose spores are extremely resistant to drying, UV radiation and are capable of surviving in the air for long periods.[34] These peculiar characteristics are ultimately responsible for species in this genus to grow and thrive in these examined indoor laboratory sections. Studies have shown that Gram positive bacteria predominate in dusts of animal and human origin while Gram negative bacteria predominate in dusts of plant origin.[35] This assumption also supports the results of this study since all isolated bacteria were Gram positive and their detection and frequency of occurrence is directly linked to human and animal presence, its activities and density. The results of this study also corroborate the reports of similar studies conducted in Europe which demonstrated that Gram positive bacteria are the most preponderant bacteria in indoor air environment.[36,37]

In respect to the number of isolated fungal species and their percentage frequency of occurrence, the results indicated the presence of the following fungal species in the indoor laboratory environments of Obong University, viz: *Aspergillus flavus* 7 (25%), *Aspergillus niger* 8(28.5%), *Penicillium chrysogenum* 4 (14.3%), *Rhizopus spp*. 5 (17.9%) and *Fusarium spp*. 4 (14.3%). The results of this study showed the dominance of *Aspergillus* with percentage frequency of 15 (53.5%). This result is similar to that obtained from a study in Ebonyi State University, Abakaliki, Nigeria in which *Aspergillus spp*. were reported as the most predominant fungal isolates.[38] The abundance of fungal species in indoor laboratory environments constitutes a significant health threat to students and staff alike as most of these species are potential human pathogens. For instance, *A. flavus* and *A. niger* could cause human infection by colonizing human respiratory tract and can also act as a potent allergen resulting in aspergillus asthma and allergic broncho pulmonary aspergillosis.[39] The reported fungal genera in this study seem to be the most frequently isolated airborne fungi genera in other regions. For instance, in a study carried out at United Arab Emirates, *Aspergillus* and *Penicillium* were the common genera of fungi frequently isolated from the air of hospitals (8) and in the industrial town of Helwan, Egypt.[40] Previous study in the Basrah city of Iraq also revealed the dominance of *Aspergillus*, *Penicillium* and *Fusarium.*[41]

It is also interesting to note that the level and distribution of the airborne bacteria and fungi in this study varies among the different laboratory sections studied. As revealed, more of these airborne microbes were isolated from the LAR, followed by MLS with the least recorded in the LR. This is in consistence with that of previous studies which showed that the percentage rate of distribution of airborne bacteria and fungi can be affected by various environmental factors.[42,43,41] These factors include temperature, air dust, humidity, human/animal presence, activities and density, soil dirt and sanitary conditions. Other factors that influence the level and distribution of these airborne microbes

include type of cultivation medium, sampling location and height from which the samples were collected. In this study, a thorough look at the three laboratory sections studied revealed that there were high similarities in terms of these environmental factors. Therefore, the observed differences in percentage frequency of occurrence and distribution of these isolated airborne species are more likely due to animal/human density and activities, air dust as well as the sanitary condition of the study areas.

## CONCLUSION

Three bacterial species and four fungal species were isolated and identified from the indoor air environments of the three laboratory sections of Obong University located in Etim Ekpo Local Government Area of Akwa Ibom State. The levels of indoor airborne bacteria and fungi in these sections were found to be within the acceptable and permissible limits of microbial load ≤500 CFU/$m^3$. It was also found that most of the isolated bacterial and fungal species do not directly pose a serious threat to human health considering the obtained degree level of air pollution within the sampling periods. However, inhalation of aerosolized particles or exposure to some of the isolated microorganisms that have been proven to possess potent pathogenic capabilities might cause some human respiratory diseases. Therefore, implementation of appropriate strategies in school laboratories aimed at reducing the number of indoor airborne bacteria and fungi would have significant benefits towards preventing human airborne disease transmission.

**Conflict of Interest:** None

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