

Original Article

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Bacteriological assessment of the indoor air quality of the lecture rooms in the Faculty of Life Sciences, University of Benin, Nigeria

Magdalene A. Osaghae, Osaro J. Williams, Babatunde E. Ogbe, Cedric Obasuyi, Cyprian E. Oshoma✉

Department of Microbiology, Faculty of Life Sciences, University of Benin, P.M.B. 1154, Benin City, Nigeria

ABSTRACT

Objective: To assess the bacteria load of lecture rooms in the Faculty of Life Sciences, University of Benin, Benin City, Nigeria.

Methods: Air sampling using settle plate method in lecture rooms was carried out for two months. The temperature and relative humidity of the sampled areas were determined while the bacteriological analyses were carried out using the standard microbiological methods. Virulent factors and antibiotics susceptibility profile of the isolates were analyzed.

Results: The lecture room with the highest bacterial, coliform and Staphylococci count was plant biology and biotechnology lecture room with values $4.84\pm0.82\times10^3$, $4.30\pm0.51\times10^3$ and $3.52\pm0.89\times10^3$ CFU/m^3, respectively, in the two months dectected. The identified bacterial isolates were *Lactobacillus delbrueckii*, *Aeromonas (A.) hydrophilia*, *Enterobacter intermedius*, *Serratia liquefacias*, *Pseudomonas* spp., *Micrococcus luteus*, *Acineobacter baumanii*, *Lactobacillus fermenti*, *Serratia marcescens*, *A. veronii*, *Streptococcus* spp., *Staphylococcus aureus*, *Corynebacterium* spp. The isolate with the highest frequency of occurrence was *Staphylococcus aureus*. Bacterial isolates with the highest virulence factors of 100 % was *A. veronii*. The antibiotic susceptibility profile showed that all Gram-negative bacterial isolates were susceptible to Sparfloxacin antibiotic. Isolate with the highest multiple antibiotic resistance index of 0.6 was *Acineobacter baumanii*.

Conclusions: To maintain air quality, constant monitoring of parameters like temperature and humidity that promote the presence organisms in the air, reducing the number of occupants, ensuring a well-functioning ventilation system, and implementing regular cleaning routines should be practiced.

KEYWORDS: Bacteria load; Lecture rooms; Indoor air quality; Temperature

1. Introduction

Indoor air quality refers to the air within and around buildings and structures especially as it relates to health and comfort of building occupants[1]. As we spend most of our time indoor, it is easy to understand that the most important environment in relation to our health is the indoor environment[2,3]. Indoor air quality has been a well-known problem since late 1970s. Its significant impact on human health has been addressed several times by the World Health Organization in various documents and meetings and has been carried out in various levels like capacity buildings in country or regional levels and developing guidelines for indoor air quality[4,5]. Indoor air pollution can be generated inside homes or buildings

Significance

Bacteriological air quality of lecture rooms is a relevant assessment carried out to know the composition of the air bacterial flora in the academic environment. Our investigation reported high bacterial load that are potential pathogenic isolates with high multiple antibiotic resistance index. The survival of these bacteria in the lecture rooms of University of Benin may be due to a high temperature, relative humidity and wrong usage of antibiotic.

✉To whom correspondence may be addressed. E-mail: cyprian.oshoma@uniben.edu

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through occupant's activities such as cooking, smoking, use of electronic machines, the use of consumer products[2,6].

Studies on indoor air quality have linked exposure to microbes in indoor to a variety of illnesses like microbial infections, toxicity and respiratory diseases[1,6]. The biological contamination of indoor air is caused by bacteria, yeast and moulds[5,7]. They are known to cause infections to living cells and can also secrete some toxic substances harmful to human health[8]. Epidemiological report stated that high microbial concentration in the air can cause allergy and even at low concentrations of some microorganisms can cause serious diseases[8–10]. It was reported that about 30% of human health problems, such as tiredness, headaches, decrease of concentration, memory and intellectual work ability[11], relevant to the indoor air quality, was caused by human microbial flora[7,10]. Also, pathogenic microorganism concentration is higher in indoor than that of outdoor air[8,10].

Air pollution has become an issue of great concern because of its impact on the health of people. It was estimated in 2018 that 3.8 million people die yearly due to air pollution within household and estimatedly nine out of 10 breathe in poor quality indoor air[12]. Over the years, controlling air pollution has proven difficult due to the difficulty of identifying and observing the contaminants[13]. It is clear that even at low air pollutant concentrations, prolonged exposure to indoor anthropogenic activities can result in serious health concerns for humans as well as a deterioration of indoor air quality[1]. Globally, indoor air pollution has been identified as the third leading cause of disability-adjusted life years[14]. Therefore, identifying the sources of air pollution is essential for efficient control of indoor air quality.

Air microbial quality in lecture rooms is of great concern for the students, particularly those with immune compromise[5]. These students are known to spend an average time of around 8 h in the lecture rooms per day. Good indoor air quality (IAQ) in the lecture rooms is an interaction of efficient ventilation, environmental factors and microbial compounds that cannot induce health risk to the occupants[9]. Inadequate IAQ in the lecture rooms could create unconducive environment for learning. In an academic environment, IAQ of lecture rooms is very important thus ensuring conducive learning environment[15]. Studies have shown that air microflora characterization in lecture rooms differ greatly in terms of time, location, ventilation and season[16]. Some implicated bacteria and fungi species found in lecture rooms were *Staphylococcus* spp., *Micrococcus* spp., *Enterococcus* spp., *Serriatia* spp., *Klebsiella* spp. and *Bacillus* spp., *Aspergillus* spp., *Penicillium* spp. and *Fusarium* spp[5,10,17]. This is mainly influenced by the inflow of students and their activities such as sneezing, coughing, talking and yawning[18].

2. Materials and methods

2.1. Sampling area and collection

This study was carried out at the Faculty of Life Sciences lecture rooms, University of Benin, Benin of Nigeria. The lecture rooms sampled were Department of Microbiology (400 level classroom), Department of Plant Biology and Biotechnology (400 level classroom), Department of Optometry (twin lecture room 2), Department of Science Laboratory and Technology (SLT classroom), Department of Environmental Management and Toxicology (EMT lecture room) and Department of Animal and Environmental Biology (400 level classroom). These sampling areas were chosen for their varied sizes and population densities. The Faculty of Life Sciences at the University of Benin is one of the largest, housing over 4 000 students. The selected sampling areas are the most active, hosting seminars, presentations, lectures, and exams, making them ideal for sampling. Samples were collected once a month from two months. Sampling was carried out using settle plate method. The petri dishes containing nutrient agar, macconkey agar, and mannitol salt agar were placed 1 m above floor level and exposed to the air for a period of 15 min while the environmental parameters were measured[17]. After sample collection, incubation was carried out at 37 ℃ for 24 h-48 h.

2.2. Enumeration and identification of bacterial isolates

The incubated plates were examined with visible discrete colonies and counted. The air bacterial flora were evaluated as colony forming units per cubic meter (CFU/m³) based on the formula stated below:

$$CFU/m^3 = (5a \times 10\,000)/bt$$

where a stands for Number of colonies counted in the Petri dish, t stands for time of exposure (15 min), and b is equal to πr^2 (The radius of the petri dish used in this study was 5.07 cm^2).

From the NA plates, colonies were randomly picked and repeatedly sub-cultured on NA for purification. Purified bacterial isolates were stored in NA slants for further studies. The purified bacterial isolates were identified by morphology, Gram's reaction and biochemical test using the scheme in Bergey's manual of determinative bacteriology[19,20]. All assays were carried out in triplicates, means and standard deviations (SD) were determined using Windows® Microsoft Office Excel version 2013. However, *t*-test was used for statistical comparison of the data for bacteria counts from the different lecture rooms.

2.3. Detection of virulence factor tests

2.3.1. Lipase activity

The isolates lipase activity was assayed on tryptone soy agar (TSA) plates supplemented with Tween 80 (1 %v/v). The plates of TSA were spot inoculated with the isolates and incubated at 37℃ for 24 h. Clear halo surrounds the areas where the lipase producing organism has grown indicated the production of lipase.

2.3.2. Protease activity

Isolates extracellular protease activity was assayed on TSA plates supplemented with 1 % casein (v/v). The isolates were inoculated on 1 % casein supplemented TSA plates and incubated at 37℃ for 24 h-48 h. Clear zones around the colonies due to casein hydrolysis indicated positive result while no clearance was considered a negative result.

2.3.3. DNA degrading activity

The isolates DNA degrading activity was tested using DNase agar plates. The isolates were inoculated on DNase agar plates and incubated at 37℃ for 24 h-48 h. When DNA is hydrolysed, methyl green is released turning the medium colourless around the test organism. Where there is no degradation of DNA, the medium remains green[21].

2.3.4.Gelatinase production

The gelatinase production of the isolates was assayed in a nutrient gelatin medium. The isolates were inoculated on gelatin medium and incubated at 37℃ for 24 h-48 h. Zones of clearance in the media indicated the presence of gelatin-liquefying microorganisms. No zone of clearance indicates a negative result[21].

2.4. Antibiotics susceptibility profile

A pure single colony grown on nutrient broth for 24 h was used for the antibiotic susceptibility profile. A liquid suspension of the isolates was prepared and compared to the MacFarland solution to determine the number of organisms in a 0.5 mL concentration of barium sulfate solution. The antimicrobial sensitivity profiles of the identified isolates were determined using the disk diffusion method using Mueller Hinton agar (MHA) plates. The antibiotic discs used were: Septrin (SXT) 30 µg, amoxicillin (AM) 30 µg, chloranphenicol (CH) 30 µg, gentamicin (CN) 10 µg, ciprofloxacin (CPX), pefloxacin (PEF) 30 µg, augmentin (AU) 30 µg, tarivid (OFX), streptomycin (S) 30 µg and sparfloxacin (SP) 10 µg. The MHA plates were inoculated with the various isolates using sterile swabs as described by Cheesbrough[20], antibiotic disks were placed on the surface of inoculated agar plates using sterilized forceps. The inoculated plates were incubated at 37℃ for 24 h. Clear Zones, as zones of inhibition, were measured with a ruler in millimeters (mm) and compared with a standard interpretation chart based on performance standards for testing antimicrobial susceptibility CLSI[22] used to categorize the isolates as susceptible, intermediate or resistant.

The multiple antibiotic resistance (MAR) index of the bacterial isolate is defined as x/y, where 'x' represents the number of antibiotics to which the test isolate displayed resistance while 'y' represents the number of antibiotics to which the isolate was subjected[23].

3. Results

The heterotrophic count of bacterial of various lecture rooms for a period of two months is shown in Figure 1. The highest bacterial count was recorded in the second month from PBB lecture room while the lowest was recorded from EMT lecture room 1 the first month with values $4.84\pm0.82\times10^3$ and $0.37\pm0.14\times10^3$ CFU/m^3 respectively.

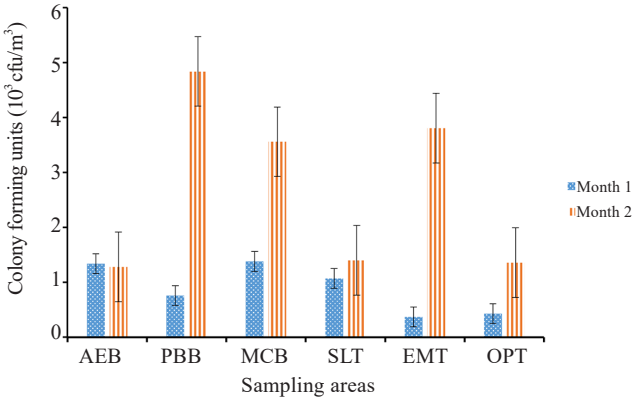

Figure 1. Heterotrophic bacteria count of various lecture rooms in the Faculty of Life Sciences.Values represent the mean of three replicates and error bar represents standard deviation. AEB: Room of animal environmental biology; PBB: Room of plant biology and biotechnology; MCB: Room of microbiology; SLT: Room of science laboratory and technology; EMT: Room of environmental management and toxicology; OPT: Room of optometry.

The coliform count of various lecture rooms for a period of two months is shown in Figure 2. The highest coliform count was recorded in PBB lecture room with a value of $4.30\pm0.51\times10^3$CFU/m^3 in the second month of sampling and the lowest recorded in the EMT room $0.18\pm0.06\times10^3$ CFU/m^3 in the first month of sampling.

Table 1. Temperature (℃), relative humidity (%) and population of various lecture rooms.

Locations	Temperature		Humidity		Population	
	Month 1	Month 2	Month 1	Month 2	Month 1	Month 2
AEB	27.96± 0.57	31.40 ± 0.12	78.23 ± 0.95	71.60 ± 0.95	30	27
PBB	22.63 ± 0.06	31.00 ± 0.10	77.60 ± 0.36	70.60 ± 0.10	20	103
MCB	27.97 ± 0.15	30.77 ± 0.06	75.15 ± 0.53	70.97 ± 0.64	36	41
OPT	29.97 ± 0.15	29.77 ± 0.10	74.47 ± 0.20	75.60 ± 0.35	9	50
SLT	29.47 ± 0.06	30.83 ± 0.15	74.97 ± 0.40	73.07 ± 0.78	25	45
EMT	30.20 ± 0.06	31.10 ± 0.25	71.77 ± 0.15	72.57 ± 0.45	8	116

Values represent the mean ± standard deviation (SD) of three replicates. AEB: Animal Environmental Biology; PBB: Plant Biology and Biotechnology; MCB: Microbiology; SLT: Science Laboratory and Technology; EMT: Environmental Management and Toxicology; OPT: Optometry.

The staphylococcal count of the various lecture rooms for a period of two months is represented in Figure 3. The highest count was observed in PBB lecture room in the second month of sampling and the lowest recorded in EMT lecture room in the first month with values $3.52 \pm 0.89 \times 10^3$ and $0.07 \pm 0.05 \times 10^3$ CFU/m^3 respectively.

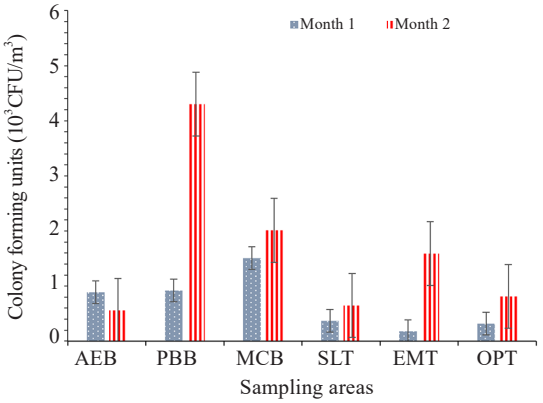

Figure 2. Coliform counts on the various lecture rooms in the Faculty of Life Sciences.Values represent the mean of three replicates and error bar represent standard deviation. AEB: Animal Environmental Biology; PBB: Plant Biology and Biotechnology; MCB: Microbiology; SLT: Science Laboratory and Technology; EMT: Environmental Management and Toxicology, OPT: Optometry.

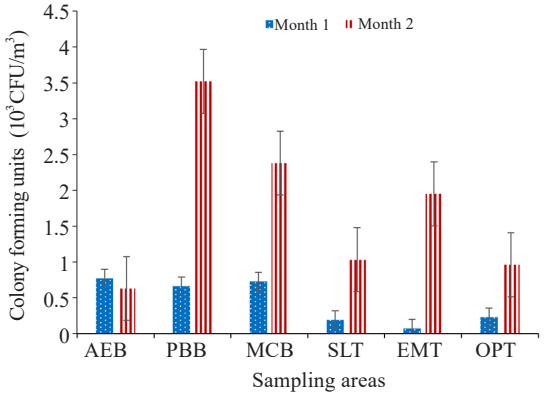

Figure 3. Staphylococcal count of the various lecture rooms in the Faculty of Life Sciences.Values represent the mean of three replicates and error bar represent standard deviation. AEB: Animal Environmental Biology; PBB: Plant Biology and Biotechnology; MCB: Microbiology; SLT: Science Laboratory and Technology; EMT: Environmental Management and Toxicology; OPT: Optometry.

The temperature, relative humidity and population count of the various lecture rooms measured for a period of two months is represented in Table 1. The highest temperature was observed in AEB lecture room in the second month and the lowest was observed in PBB lecture room in the first month with values 31.40 ± 0.12 and 22.63 ± 0.06℃ respectively. The highest relative humidity was observed in AEB lecture room in the first month and the lowest was observed in PBB lecture room in the second month with values 78.23% and 70.60% respectively. The highest population count was observed in EMT lecture room in the second month with a count of 116 and the lowest measured in SLT lecture room with a count of 9 in the first month.

The identified bacterial isolates using cultural, morphological and biochemical characteristics and frequency of occurrence are shown in the Table 2. The isolate with the highest frequency of distribution of 11.53 % was *Staphylococcus (S.) aureus*.

The phenotypic virulence factor tests are shown in Table 3. This reveals the presence of phenotypic factors that aid in pathogenicity of the isolates. All except *Lactobacillus (L.) fermenti* and *Streptococcus* spp. were positive for gelatinase.

Table 2. Frequency of distribution and percentage of occurrence of bacterial isolates.

Isolates	Percentage (%)
Lactococcus delbrueckii	11.50
Aeromonas hydrophilia	7.69
Enterobacter intermidius	5.76
Serratia liquefacias	5.76
Pseudomonas spp.	7.69
Micrococcus luteus	9.62
Acinetobacter baumanii	7.69
Corynebacterium spp.	9.62
Serratia marcescens	3.85
Lactobacillus fermentii	5.76
Streptococcus spp.	5.76
Staphylococcus aureus	11.53
Aeromonas veronii	3.85

The results of the antibiotics susceptibility profile performed on isolates showed that all the Gram-positive isolates were sensitive

to the antibiotic gentamycin while all the Gram-negative isolates were susceptible to sparfloxacin. The most sensitive isolates were *Micrococcus (M.) luteus* and *Serratia (S.) marcescens* against the tested antibiotics (Table 4).

The multiple antibiotics resistance MAR index of the bacterial isolates are shown in Figure 4. The highest MAR index of 0.6 was from *Aeromonas (A.) veronii* and the lowest 0.1 was from *M. luteus* and *S. marcescens*.

Table 3. Virulence factors test of bacterial isolates.

Isolates	Lipase	Protease	DNAse	Gelatinase	Percentage of activity (%)
Lactococcus delbrueckii	-	+	-	+	50
Aeromonas hydrophilia	+	-	+	+	75
Enterobacter intermidius	-	-	-	+	25
Serratia liquefacias	+	-	-	+	50
Pseudomonas spp.	-	-	-	+	25
Micrococcus luteus	+	-	-	+	50
Acinetobacter baumanii	-	-	-	+	50
Corynebacterium spp.	+	+	-	+	75
Serratia marcescens	-	-	+	+	50
Lactobacillus fermentii	-	-	-	-	0
Streptococcus spp.	-	+	-	-	25
Staphylococcus aureus	-	-	-	+	25
Aeromona sveronii	+	+	+	+	100

Percentage of activity= number of positive test/total number of tests × 100.

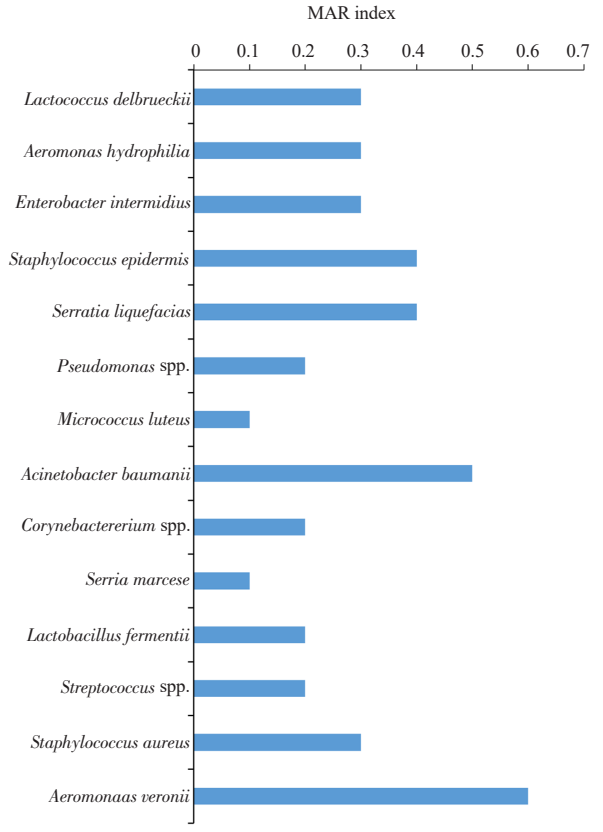

Figure 4. MAR index value of bacterial isolates.

4. Discussion

Excessive bioaerosol contamination can cause serious health effects like sick building syndromes[7]. The aim of this experiment is to assess quantitatively and qualitatively the microbial composition of indoor air of lecture theatres.

The bacterial counts after second month were found to be high in PBB, MCB and EMT lecture rooms and statistically not significant but significantly different from other rooms (P<0.05). The high bacterial counts could be explained as a result of variation in the population density[3]. Changes in weather conditions, increasing temperature and lower humidity during sampling, and occupants greater number may also contribute to the increase in bacterial count[24]. All the lecture rooms are rated as contaminated environment because the count obtained exceeded the WHO health risks of biological agents in indoor environments with a permissive standard of less than 1 000 CFU/m^3[6]. These findings are similar to the work of Hayleeyesus FS *et al.*, on the quantitative assessment of bioaerosols in indoor dormitories, in which the microbial load was higher with lower humidity and greater number of students in the dorm[25].

The highest count was observed in PBB lecture room in the second month and the lowest was observed in EMT lecture room in the first month. The variation of bacterial load may be due to the proximity of the sampling area to waste dump, which can serve as a source of contaminants, the environmental hygiene of the sampling hall and the activities of occupants like walking that could resuspend microbial particles[26,27]. This supports the findings of in the review of microbial air quality near landfill sites and their implications to public health by Odonkor TS *et al.* The microbial load was higher at areas closer to the dump sites[28].

ASHRAE standard 55[29] suggested the indoor temperature range must be between 23 ℃-26 ℃; while, the recommended indoor relative humidity must be between 30%-70%. The values obtained from this study showed that the indoor temperature and relative humidity recorded were above recommended standard. Meteorological parameters such as temperature and humidity are important factors influencing the survival and vitality of airborne bacteria[30]. The variation could be the sampling period was during wet season thus, having a higher relative humidity and temperature above the recommended values[17,31].

A total of thirteen bacterial isolates were identified, namely, *S. epidermidis*, *S. aureus*, *Streptococcus pyogenes*, *Klebsiella pneumonia*, *Proteus vulgaris*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus* spp. and *Micrococcus* spp. Many of these organisms isolated were similar to those isolated from other research on indoor air

Table 4. Antibiotics sensitivity test for Gram-positive bacterial isolates in diameter (mm).

Gram-positive isolates	Z(20 µg)	AM(30 µg)	R(25 µg)	CPX(10 µg)	S(30 µg)	SXT(30 µg)	E(30 µg)	PEF(10 µg)	CN(10 µg)	APX(30 µg)
Lactococcus delbrueckii	R	R	I	S	S	S	S	S	S	R
Micrococcus luteus	S	S	I	S	I	R	I	S	S	S
Lactobacillus fermentii	R	R	S	S	I	S	S	S	S	S
Streptococcus spp.	R	R	S	S	S	S	I	S	S	S
Staphylococcus aureus	R	R	S	S	S	S	S	R	S	R
Corynebacterium spp.	R	S	S	S	I	R	I	S	S	I
Gram-ve isolates	S(30 µg)	SXT(30 µg)	CH(30 µg)	SP(10 µg)	CPX(10 µg)	AM(30 µg)	AU(30 µg)	CN(10 µg)	PEF(10 µg)	OFX(10 µg)
Aeromonas hydrophilia	I	S	R	S	S	R	R	I	S	S
Enterobacter intermidius	R	S	S	S	S	R	R	S	S	S
Serratia liquefacias	S	R	R	S	I	S	S	S	S	R
Pseudomonas spp.	R	S	R	S	I	S	S	S	S	S
Acinetobacter baumanii	R	R	R	S	S	R	R	R	S	S
Serratia marcescens	I	I	I	S	S	R	I	S	S	S
Aeromonas veronii	R	R	R	S	S	R	R	S	R	I

Note: SXT: Septrin; CH: Chloraphenicol; SP: Sparfloxacin; CPX: Ciprofloxacin; AM: Amoxacillin; AU: Augmentin; CN: Gentamycin; PEF: Pefloxacin; OFX: Ofloxacin; S: Streptomycin; APX: Ampiclox; Z: Zinnacef; R: Rocephin; SXT: Septrin; E: Erythromycin; S= Sensitive (19-35); I= Intermediate (14-18); R=Resistant (0-13).

quality[32–35]. The predominant bacteria isolated were *S. aureus* (11.53%)and *L. delbrueckii* (11.50%); this agrees with findings by Modebelu[36] who also had *S. aureus* as the predominantly isolated bacterium from indoor environment. Findings from this study also agrees with reports by Ekhaise FO *et al.* and Sheik GB *et al.* who had *Staphylococcus* species and *Bacillus* species as dominantly isolated bacteria[7,33,35]. The prevalence of isolated bacteria is an indication of the ubiquitous nature of the isolates. These genera of bacteria have been shown to be amongst the most common bacteria genera often isolated from air. Previous studies have also shown that people occupying or visiting enclosed spaces play a dominating role in the creation of indoor microbiological environment[37].

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 derives from human presence[3]. *Staphylococcus* is found in all individuals, and usually expelled from the respiratory tract through the nose and mouth which may also account for their presence in the environment[37]. Since some of the *Staphylococcus* species and *Micrococcus* species belong to normal flora of the human skin, it is likely that these microorganisms may be originated from the skin flora of the individuals within the rooms. However, *S. aureus* may cause bacteremia and gastrointestinal infections[36] and cause disease through invasion and toxin production such as abscess, pneumonia, diarrhea and the most feared toxic shock syndrome[35]. Also, these microorganisms are considered potential candidates involved in the establishment of sick building syndromes[3]. *A. veronii* appeared least in the sampling area with a percentage of 1.76. The reason could be because it is more associated with water environment[38].

The phenotypic virulence factors tests carried out on the bacterial isolates reveal that all isolates except *Streptococcus* sp and *L. fermentii* possess at least 25% of the virulent factors. The bacterial isolates possess virulence factors that enhance their pathogenicity[39]. Studies of the virulence factor carried out showed some isolates to have 50% pathogenicity[39,40], which means they possess half the virulent traits tested on them. These traits confirmed the isolates to be pathogenic and may likely cause infections to susceptible host mostly in immunocompromised individuals[21]. These isolates could pose a threat to the quality of air in the lecture rooms.

The antibiotics susceptibility pattern of these bacterial isolates was observed. That different antibiotics had variable actions against the different bacterial isolates. A total of 10 commonly used antibiotics were used against Gram-positive and Gram-negative bacterial isolates each. Expect for *M. luteus*, all Gram-positive isolates were shown to be resistant to zinnacef antibiotics. All the Gram-positive bacteria were found to be sensitive to Ciprofloxacin and Gentamycin while the Gram-negative bacteria showed no resistance to Sparfloxacin, and Ciprofloxacin, which revealed these antibiotics as the drug of choice. This finding is consistent with the study of antibacterial activity and therapeutic usage, which revealed that Ciprofloxacin was more active against Gram-negative bacteria[41]. Studies by Shariati[42] on the resistance mechanism of bacteria against ciprofloxacin and innovative approaches to increasing the efficacy also showed that all isolates, both Gram-positive and negative, were sensitive to the antibiotic. Ciprofloxacin was effective against multiple gram-positive bacterial isolates, in line with my investigation.

The MAR index was also observed with *Acineobacter baumanii* and *A. venonii* having the highest index value of 0.6, *M. luteus* and *S. marcese* having the lowest value of 0.1. If the bacterial isolates from

the indoor air had a MAR index higher than 0.2, it suggests that antibiotics were being overused in the surrounding environment[39]. This result is comparable to that of Adebayo-Olajide and Olorunfunmi[43] who examined the antibiotic sensitivity patterns of bacteria isolated from indoor air of female hostels in a tertiary institution. In that investigation, the MAR index values of all the bacteria recovered from the indoor air were greater than 0.2, with the exception of *Micrococcus* spp., which had a value of 0.1. Misuse and the use of inferior medications to treat bacterial infections may be the cause of resistance to these antibiotics. This may result in long-term sickness and even death in susceptible individuals, such as those with weakened immune systems, raising concerns about public health[22].

5. Conclusions

The air quality in the lecture rooms under investigation has varying bacteriological qualities depending on the Departments within the Faculty. The investigation has shown that the bacterial counts were higher than the acceptable limit. It was reported that the amount of bacteria in the air is influenced by human activity, ventilation, and humidity. Because the quality of the indoor air that people breathe has an impact on their health, it is crucial to monitor the indoor air quality in lecture rooms in Faculties. Keeping lecture halls clean on a regular basis is the best way to enhance indoor air quality in educational settings.

Conflict of interest statement

The authors claim there is no conflict of interest.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' contributions

This work was carried out in collaboration between all authors. Osaghae MA, Williams OJ and Oshoma CE conceived and designed the experimental plan, also wrote the article. Osaghae MA, Williams OJ and Obasuyi C performed the Lab experiments. Osaghae MA, Williams OJ, Obasuyi C and Ogbe BE carried out data collection and analysis. Obasuyi C and Ogbe BE contributed reagents/materials/analysis tools. The final manuscript was read and approved by all the authors.

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