

Indoor Air Quality of Selected Lecture Theatres in Faculty of Life Sciences, University of Benin

Idemudia, I.B.^{1,2*}, Momoh, A.M.¹ and Michael, E.I.¹

Page | 4250

¹Department of Microbiology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria

²Applied Environmental Bioscience and Public Health Research Group, University of Benin, Benin City, Edo State

Date Received: 23-12-2021

Date Accepted: 27-01-2022

DOI: <https://doi.org/10.48198/NJPAS/21.B120>

ABSTRACT

The presence of airborne microbes can be detrimental to mankind. Research on bacteriological pollution of indoor air in selected lecture theatres of Life Sciences Faculty, University of Benin, was carried out. Surveys were conducted in the period of July-September, 2019. Microbiology lecture Theatre, Environmental Management and Toxicology Lecture Theatre, Animal and Environmental Biology (200 Level) Laboratory, Microbiology (400 level) Laboratory, Plant Biology and Biotechnology (200 level) Laboratory and Microbiology Postgraduate Laboratory were the sampling areas. Air samples were obtained using passive sedimentation method (settle plate method). Visible colonies were expressed in colony forming units per meter cube (cfu/m³) and pure discrete colonies were enumerated and characterized. Bacteria counts ranged from $1.83 \pm 0.35 - 18.34 \pm 2.83$ ($\times 10^2$ cfu/m³) in July 2019. In August 2019, Bacteria counts ranged from $3.14 \pm 0.71 - 33.27 \pm 65$ ($\times 10^2$ cfu/m³). In September 2019, values ranged from $3.67 \pm 0.71 - 29.60 \pm 6.01$ ($\times 10^2$ cfu/m³). The evaluation of air quality in the designated sampling points based on the sanitary standards formulated by the European commission revealed that 8 of the sampling points showed high level of pollution (44.44%) and 4 sampling points had very high level of contamination (22.33%). Three bacterial isolates were identified as *Staphylococcus epidermis*, *Staphylococcus aureus* and *Bacillus cereus* and they are of public health importance. High influx of students, architectural design of rooms and systems of ventilation are factors that can influence the indoor airborne bacterial population.

Keywords: Air quality, Bacterial isolates, Contamination, Indoor air, Lecture hall

Introduction

Researches associated with disease outbreak has revealed increasing awareness on the existence and risk of airborne microorganisms as well as potential health problems caused by them. Aerosols of biological origin are single or clustered microbial isolates that binds to liquid and solid particles in the air. Suspended microorganisms in

the air or attached solid or liquid particles are referred to as bio-aerosol in the air or gas (Pepper and Gerba, 2014). Bio-aerosol is composed of microbes such as spore-forming yeast, bacteria and its spores, moulds, microbial fragments, metabolites and viruses. Their size ranges from 0.001 μ m to 100 μ m in diameter (Kim *et al.*, 2017).

Corresponding Author: Iyore B. Idemudia

Department of Microbiology, Faculty of Life Sciences, University of Benin, Benin City, Edo State

Email: iyore.idemudia@uniben.edu



Airborne pathogens are primary causes or causative agents of infectious disease, hence aerobiology is a vital tool in disease transmission and control (Fernstrom and Goldblatt, 2013). Microbes (e.g., bacteria, viruses and spores of fungi) from infectious sources with prospect of dissemination over long distances with support of air current. They ultimately get gulped by individuals without pre-contacting the infections (Coronado *et al.*, 1993; Fiegel, 1996; Ellis, 2010; van Seventer and Hochberg, 2017).

The importance of air quality cannot be over-emphasized as approximately 90% of people devote more of their time staying indoors (Colls, 2002). Individuals are exposed to conditions of indoor air comparatively more than outdoors (Ellis, 2010). Consequently, it is imperative that to sustain good Indoor Environment Quality (IEQ) in University lecture theatres as poor IEQ leads to Sick Building Syndrome (SBS) as well as Building Related Illness (BRI) (Rajapaksha and Jayasooriya, 2018).

University lecture theatres are engaged by a multiplicity of class sizes and for variable durations. Lecture theatres are mostly designed to be large to aid ventilation. If the Indoor Air Quality (IAQ) in the lecture theatres are inadequate, it tends to create unconducive environment for learning. The IAQ is very important in an academic institutes to ensure there is conducive learning environment (Ellis, 2010; Sulaiman *et al.*, 2013).

Contamination of indoor air is mostly by microorganisms such as bacteria, moulds and yeast. Basically, their presence varies between locations and are influenced by environmental conditions. Bio-aerosols are microbial particles, vapor, gases or fragments that biologically originated and predominate in the air (Sekulska, 2007). Bio-aerosols are of different sizes (20nm to >100 µm) and structure dependent on their sources, mechanisms of aerosolization and site environmental conditions (Pillai and Ricke, 2002). Due to their light weight, they are easily

transported as airborne particles, transferred and displaced concurrently from place to place (Mandal and Brandl, 2011).

High concentration of bio-aerosol is a major factor of indoor air quality. They are introduced to the air by humans during coughing, sneezing and talking, thereby spreading the microorganisms to other individuals and indoor environments with increased risk of infecting a close and or immunocompromised individual (Moldoveanu, 2015; Idemudia and Ekhaise, 2019).

The aim of this research was to enumerate and identify airborne bacterial isolates from selected lecture theatres in the Faculty of Life Sciences, University of Benin.

Materials and Methods

Sampling Area

Samples were collected from six different lecture theatres located within the Faculty of Life Sciences. They include; Microbiology lecture Theatre, Environmental Management and Toxicology lecture Theatre, Animal and Environmental Biology (200 Level) Laboratory, Microbiology (400 level) Laboratory, Plant Biology and Biotechnology (200 level) Laboratory and Microbiology Postgraduate Laboratory.

Media Preparation

Nutrient agar was the medium used for the isolation of airborne bacterial isolates. Media was aseptically prepared with adherence to the manufacturer's instruction, Nystatin (an antifungal agent) was added to prevent fungi growth. It was decontaminated at 121°C for 15 min and aseptically dispensed into sterile Petri dishes at 50°C (Cheesbrough, 2006).

Sample collection

Samples were collected once a month from July-September, 2019 between 11 am and 1 pm, using the settle plate method. Sterile prepared plates of nutrient agar were placed 1 m above ground level

and about 1m away from doors, windows or any major obstacle for 15 min. Thereafter, the plates were transported immediately to the laboratory and incubated at 37 °C for 24 h. Thereafter, the colonies were sub-cultured onto a new fresh medium to obtain pure isolates (Muhammad *et al.*, 2017).

Enumeration of Isolates

Visible discrete colonies on sample plates were counted and values converted to colony forming units per meter cube (cfu/m³) of the samples using the formula below. The air quality was evaluated based on the European Commission Sanitary Standards (Idemudia and Ekhaize, 2019).

$$\text{cfu/m}^3 = \frac{a \times 10000}{p \times t \times 0.2}$$

where;

a: Number of colonies counted in the Petri dish

p: Surface area of the 9cm diameter Petri dish (πr^2)

t: Time of exposure (15min)

Characterization and identification of isolates

Discrete colonies were subcultured into appropriate agar media. Pure bacterial culture plates were subjected to identification using cultural morphological and biochemical analysis. Some of the key tests used for the identification include: Gram staining, catalase, oxidase, coagulase, urease, indole, motility, methyl red, citrate, glucose, sucrose, lactose and maltose.

Results

Figures 1, 2 and 3 show the airborne bacterial counts from six lecture theatres in July, August and September from the respective points of sampling. Bacterial counts ranged from $1.83 \pm 0.35 - 18.34 \pm 2.83$ ($\times 10^2$ cfu/m³) in July 2019. In August 2019, Bacterial counts ranged from $3.14 \pm 0.71 - 33.27 \pm 6.50$ ($\times 10^2$ cfu/m³). In September 2019, values ranged from $3.67 \pm 0.71 - 29.60 \pm 6.01$ ($\times 10^2$ cfu/m³). The evaluation of air quality in the designated sampling points based on the sanitary standards formulated by the European commission

is shown in Table 1. Table 2 shows the identification of the bacterial isolates using the cultural, morphological biochemical characteristics. They include; *Staphylococcus epidemidis*, *Bacillus Cereus* and *Staphylococcus aureus*.

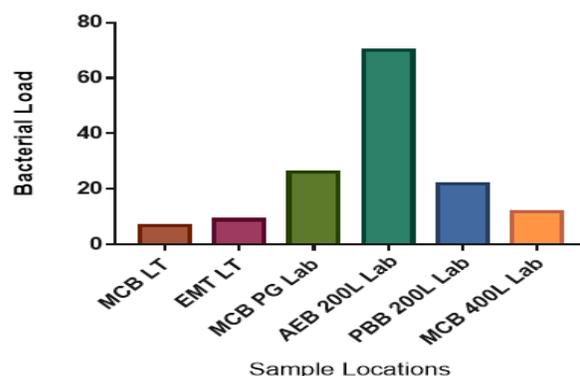


Figure 1: Airborne bacterial counts of the six lecture theatres in July, 2019

Key: MCB LT- Microbiology lecture theatre; EMT LT- Environmental Management and Toxicology lecture theatre; MCB PG Lab- Microbiology Postgraduate laboratory; AEB 200L Lab- Animal and Environmental Biology (200 level) Laboratory; PBB 200L Lab – Plant Biology and Biotechnology (200 level) Laboratory; MCB 400L Lab - Microbiology (400 level)

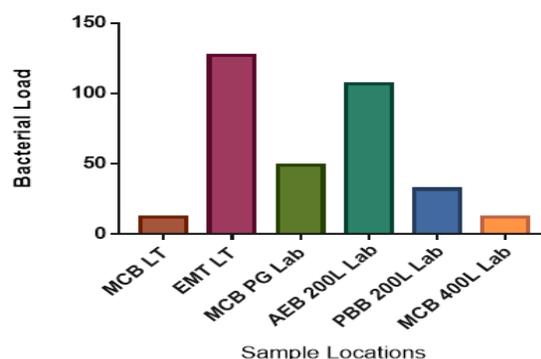


Figure 2: Airborne bacterial counts of the six lecture theatres in August, 2019

Key: MCB LT- Microbiology lecture theatre; EMT LT- Environmental Management and Toxicology lecture theatre; MCB PG Lab- Microbiology Postgraduate laboratory; AEB 200L Lab- Animal and Environmental Biology (200 level) Laboratory; PBB 200L Lab – Plant Biology and Biotechnology (200 level) Laboratory; MCB 400L Lab - Microbiology (400 level)

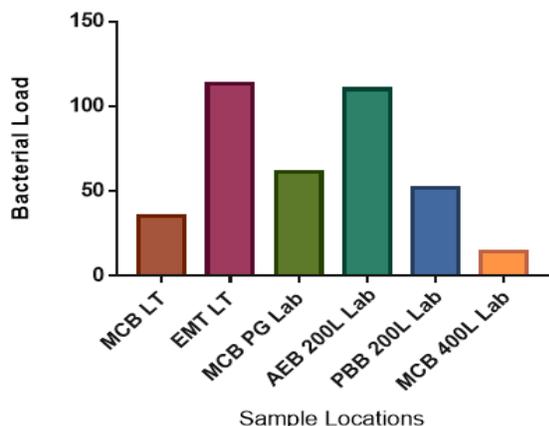


Figure 3: Airborne bacterial counts of the six lecture theatres in September, 2019

Key: MCB LT- Microbiology lecture theatre; EMT LT- Environmental Management and Toxicology lecture theatre; MCB PG Lab- Microbiology Postgraduate laboratory; AEB 200L Lab- Animal and Environmental Biology (200 level) Laboratory; PBB 200L Lab – Plant Biology and Biotechnology (200 level) Laboratory; MCB 400L Lab - microbiology (400 level)

Table 1: Evaluation of air quality in the designated sampling points based on the sanitary standards formulated by the European commission

MONTHS (2019)	MCB LT	EMT LT	MCB PG Lab	AEB 200L Lab	PBB 200L Lab	MCB 400L Lab
JULY	I	I	H	H	H	I
AUGUST	H	I	I	VH	H	VH
SEPTEMBER	H	VH	H	VH	H	I

KEY:

VALUES	DEGREE OF CONTAMINATION	CODE	CONTAMINATION LEVEL (%)
<50	Very low	VL	-
50 – 100	Low	L	-
100 – 500	Intermediate	I	6 (33.33)
500 - 2000	High	H	8 (44.44)
>2000	Very High	VH	4 (22.23)

MCB LT- Microbiology lecture theatre; EMT LT- Environmental Management and Toxicology lecture theatre; MCB PG Lab- Microbiology Postgraduate laboratory; AEB 200L Lab- Animal and Environmental Biology (200 level) Laboratory; PBB 200L Lab – Plant Biology and Biotechnology (200 level) Laboratory; MCB 400L Lab -Microbiology (400 level)

Table 2: Cultural, morphological and biochemical characteristics of the bacterial isolates.

Characteristics	Isolate 1	Isolate 2	Isolate 3
Cultural			
Shape	Grape-like	Rod	Grape-like
Elevation	Low convex	Low convex	Low-convex
Margin	Entire	Curly	Smooth
Texture	Buttery	White granular	Buttery
Opacity	+	+	Opaque
Colour	White-cream	Gray-white	Golden yellow
Size	0.5-1.5 µm	1.1-1.5 µm	0.5-1.5 µm
Morphological			
Gram staining	+	+	+
Cell type	Coccus	Rod	Coccus
Cell arrangement	Cluster	Irregular chains	Cluster
Biochemical			
Catalase	+	+	+
Oxidase	-	-	-
Coagulase	-	ND	+
Urease	+	-	+
Indole	-	-	-
Motility	-	+	-
Methyl red	-	-	+
Citrate	-	+	+
Glucose	+	+	+
Sucrose	+	+	+
Lactose	+	-	+
Maltose	+	+	+
Possible isolate	<i>Staphylococcus epidermidis</i>	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>

KEY: +Positive: -Negative: ND: Not determined

Discussion

The bacterial counts recorded in July 2019 were low as compared to August and September 2019 because the samples were collected on the first day of resumption for the semester and the student's population was low as compared to the high population of students in the other sampling period. This study supports the findings of Moldoveanu (2015), in which he stated that the bacterial load (cfu/m³) increases with students population. AEB and PBB Lecture classes had all bacterial load with degree of contamination in the high (500-2000 cfu/m³) and very high range (>2000 cfu/m³).

In this study, three bacterial isolates were identified as *Staphylococcus epidermidis*, *Staphylococcus aureus* and *Bacillus cereus*. This study supports the findings of Muhammed *et al.* (2017), who reported that *Staphylococcus aureus* and *Bacillus* sp. can be found in lecture theatres. These isolates could be associated to several infections such as gastro-intestinal tract, respiratory tract, urinary tract and skin disorders. *Staphylococcus epidermidis* and *Staphylococcus aureus* are normal flora of the human skin and nose. *Staphylococcus aureus* have been implicated in Pneumonia, skin disease and formation of abscess while *S. epidermidis* causes sinus, wound infections, boils and endocarditis. *Bacillus cereus* causes food poisoning, skin and joint infectious, septicaemia, pneumonia and meningitis (Foster, 1996; Granum and Lund, 1997; Gaur and Shenep, 2001; Widerström, 2016). The isolates most likely originated from the students and staff.

Result of this research indicated prevalence of bacterial load to be influenced by increase in the number of students and their activities in the lecture theatres as well as system of ventilation. Bio-aerosols indoor air contaminant is detrimental and causes significant health issues including sick building syndrome (Dharmage *et al.*, 2001).

Conclusion

The recognition of bioaerosol contamination and occurrence as well as the practice of good control measures help play significant roles in enhancing good air quality. Individual levels of efforts such as practicing of good personal hygiene, maintenance activities, periodic cleaning operations and appropriate ventilation system also serve in their best approach to improve indoor air quality in learning environments.

Conflict of Interest

There is no conflict of interest with respect to this article

References

- Colls, J. (2002). Air pollution; Measurement, modelling and mitigation. 2nd edition. Taylor and Francis, United Kingdom. 592pp.
- Cheesbrough, M. (2006). Distinct Laboratory Practice in Tropical Countries. Part 2. (2nd Ed). Cambridge University Press, New York, United States. 442pp.
- Coronado, V.G., Beck-Sague, C.M., Hutton, M.D., Davis, B.J., Nicholas, P., Villareal, C., Woodley, C.L., Kilburn, J.O., Crawford, J.T. and Frieden, T.R. (1993). Transmission of multidrug-resistant *Mycobacterium tuberculosis* among persons with human immunodeficiency virus infection in an urban hospital: epidemiologic and restriction fragment length polymorphism analysis. *The Journal of Infectious Diseases*, 168(4), 1052-1055.
- Dharmage, S., Bailey, M., Raven, J., Mitakakis, T., Cheng, A., Guest, D., Rolland, J., Forbes, A., Thien, F., Abramson, M. and Walters, E.H. (2001). Current indoor allergen levels of fungi and cats, but not house dust mites, influence allergy and asthma in adults with high dust mite

- exposure. *American Journal of Respiratory and Critical Care Medicine*, 164 (1), 65–71.
- Ellis, J. (2010). Indoor air quality in lecture theatres and long enclosed Public spaces. *Student Doctoral Thesis* 331pp
- Fernstrom, A. and Goldblatt, M. (2013). Aerobiology and its role in the transmission of infectious diseases. *Journal of Pathogens* 2013: Article ID 493960, 13pp.
- Fiegel, J., Clarke, R and Edwards, D. A. (2006). “Airborne infectious disease and the suppression of pulmonary bioaerosols,” *Drug Discovery Today*, 11(12), 51–57.
- Foster, T. (1996). *Staphylococcus*. In Baron, S. (editors). *Medical microbiology*, 4th edition. Galveston (TX), University of Texas Medical branch, Galveston. Chapter 12.
- Gaur, A.H. and Shenep, J.L. (2001). The expanding spectrum of diseases caused by *Bacillus cereus*. *The Pediatric Infectious Disease Journal*, 20 (5), 533-534.
- Granum, P.E. and Lund, T. (1997). *Bacillus cereus* and its food poisoning toxins, *FEMS Microbiology Letters*, 157 (2), 223–228.
- Idemudia, I.B. and Ekhaise, F.O. (2019). Bacteriological Enumeration and Air Quality of Three Major Hospitals in Benin City, Nigeria. *Journal of Science and Technology Research*, 1(2), 77-86
- Moldoveanu, A.M. (2015). Biological Contamination of Air in Indoor Spaces. In Nejadkoorki, F (editor). *Current Air Quality Issue*, 656pp.
- Pepper, I.L. and Gerba, C.P. (2014). Aeromicrobiology. *Environmental Microbiology*, 2015, 89-110.
- Pillai, S.D and Ricke, S.C (2002). Review/Synthèse Bioaerosols from municipal and animal wastes: background and contemporary issues. *Canadian Journal of Microbiology*, 48(8), 681-696.
- Rajapaksha, R.M.D.H and Jayasooriya, V.M. (2018). Investigation of the Indoor Environment Quality (IEQ) in Lecture Theatre: A Sri Lankan Case Study. *Proceedings of the 23rd International Forestry and Environment Symposium, University of Sri Jayewardenepura, Sri Lanka*. 127p.
- Sulaiman, S.A, Isa, N., Raskan, N.I. and Che Harun, N.F. (2013). Study of Indoor Air Quality in Academic Buildings of a University. *Applied Mechanics and Materials*, 315, 389–393.
- van Seventer, J.M. and Hochberg, N.S. (2017). Principles of infectious diseases: transmission, diagnosis, prevention and control. *International Encyclopedia of Public Health* 22-39.
- Widerström, M. (2016). Significance of *Staphylococcus epidermidis* in Health Care-Associated Infections, from contaminant to clinically relevant pathogen: This is a wake-up call! *Journal of Clinical Microbiology*, 54(7), 1679-1681.