Bacteriological Assessment of Indoor Air Quality in Keystone (Male) Hostel, University of Benin, Benin City

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ABSTRACT

This study examined and identified the level of bacteria present in the hostel to evaluate the potential health hazards for the residents and establish guidelines for controlling indoor air quality. Six (6) rooms were sampled out of 25 rooms at the keystone hostel, each with a height of 10 feet, and an average dimension of 9 feet by 10 feet. The study was done in July and November, 2023. Passive air sampling of settle plate method was employed. The isolates were identified using standard cultural and biochemical identification method. The outcome revealed that the concentration of bacteria isolates rose as media exposure time increased. In July, the maximum bacteria concentration was observed in room 37 at 20min (21.5×10^2CFU/m^3) and the minimum in room 49 at 20 min (0.02×10^2 CFU/m^3. The concentration of bacteria in room 48 at 20 min was (0.1×10^2 CFU/m^3), room 47 at 20 min (11.0×10^2 CFU/m^3), room 38 at 20 min (16.5×10^2 CFU/m^3), room 39 at 20 min (10.5×10^2 CFU/m^3), While for the month of November, the highest bacteria concentration was seen in room 37 at 20min (26.5×10^2 CFU/m^3) and the least at room 49 at 20 min (0.09×10^2 CFU/m^3). The concentration of bacteria at other room 48 at 20 min (0.3×10^2 CFU/m^3), room 47 at 20 min (13.5×10^2 CFU/m^3), room 38 at 20 min (19.2×10^2 CFU/m^3), room 39 at 20 min (15.1×10^2 CFU/m^3). A total of seven (7) distinct bacteria species: *Escherichia coli* (60%), *Staphylococcus aureus* (100%), *Streptococcus pyogenes* (50%), *Bacillus cerus* (30%), *Seratia marcescens* (30%), *Klebsiella spp* (50%) and *Proteus spp* (50%) were isolated and identified in four rooms (37, 38, 39, and 47), with six occupants each, while room 48 and 49 had two occupants respectively; hence bacterial load were relatively non-significant. However, *Staphylococcus aureus*, *Streptococcus pyogenes* and *Bacillus cerus* were identified as the most pathogenic isolates seen in the rooms under study. The study highlights the potential impact of occupancy levels on microbial presence within indoor spaces. The results shows that students in rooms 37, 38, 39 and 47 have a high risk of health and disease implications due to poor ventilation and overcrowding, unlike the students in rooms 48 and 49 with low risk of infectious diseases. Therefore, the study recommends a periodic indoor air quality assessment in the students' hostel, implementation of good health hygiene practices, maintaining environmental sanitation and managing the environmental factors that supports the multiplication of the bacteria especially in the dry season are crucial to preventing the spread of diseases in the hostel.

Key words: Bacteriological Assessment, Indoor Air Quality, Students Hostel

INTRODUCTION

The indoor air quality has been the center of many studies because the scientific community pays serious attention on how indoor air quality affects health, since lots of persons stay indoors than outdoors [8]. Indoor Air Quality (IAQ) means the air quality inside and around buildings and structures in respect to the health and convenience of the residents. Assessment of indoor air quality in student hostels is pertinent in school environment to mitigate the spread of infectious diseases and air pollution which are threat to human health. Clean air is a basic requirement of life, as the indoor air quality within homes, offices, schools or other private and public housings, play a key role in fostering a healthy living and well-being [21]. People literary invest 80-90% indoors, taking in around 10-14m^3 daily [20]. Lots of children and adults invest 24-30% of their day in

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school environment, requiring safe and healthy surroundings to thrive, learn, and excel [17].

Indoor air pollution is a major problem in the society and in our individual lifestyles. Effective corrective measures are urgently required to address the issue of indoor air quality: Bacterial, smoke, pollen grains, humidity, and gases let out by human activities have detrimental impact on public health [13]. Many investigations highlight the risks associated with global warming on human health as a result of the rising levels of air pollution. The previous decades have experienced an increase in the concentrations of the air pollens and pollutants. This increase aligns with growing number of persons experiencing allergic symptoms like allergic rhinitis, conjunctivitis, and asthma [16].

Worldwide, 3.8 million fatalities were credited ton indoor air pollution in 2016. Majority of deaths caused by air pollution happen in low- and middle-income countries, chiefly in Asia and Africa, closely mark by low- and middle-income countries of the Eastern Mediterranean region, Europe, and America [22]. Additionally, Bioaerosols play a role in about 5-34% of indoor air pollution [17].

Researchers have observed that microbial communities are diverse, following the different types of indoor environments such as schools, houses, and hospitals [14]. This microbial diversity could also be seen within rooms in same building; for instance, between a bedroom and a bathroom [2]. Airborne infectious diseases are relatively easy to spread in building with poor ventilation systems. The measurement of microorganisms in about 1000cfu (colony forming unit) per cubic meter of air, indicates that indoor environment may need to be investigated for microbiological contamination [19]. However, [18] States that exceeding this level does not mean that the air is unsafe or hazardous, but as a result of a delusive indicator of the presence of atmospheric normal micro flora or as a result of the universal presence of microorganisms.

School hostels may encounter more intense indoor air issues compared to other sorts of buildings, as a result of higher number of residents, improper sanitary practices in rooms, and bad ventilation system. These issues are skyrocketed by bad construction and maintenance of hostel buildings [15]. Academic performance of the students can also be affected by poor indoor air quality. Therefore, this research employed the assessment of the bacterial quality of indoor air in University of Benin, keystone hostel (Male) to raise awareness and offer perspectives for a clearer understanding of bacterial indoor air quality issues in school hostels.

MATERIALS AND METHOD

Sample Collection

Air samples were obtained from the male Keystone hostel for undergraduate in the University of Benin, Benin city, Edo state. The keystone hostel is sectioned in two series, a side for the males and the other for the females. The air sample was obtained from six male rooms, four of which were occupied by six students (room 37, 38, 39, and 47 respectively), while the other two were occupied by two students (room 48 and 49) each.

Isolation, enumeration of the bacteria

The culture media was prepared with the nutrient agar prescribe procedure, which involves the dilution of 28grams of nutrient agar in 1000ml of distilled water, then sterilized with a pressure cooker and mixed with antifungal agent to prevent growth of fungi in the media before finally dispense into petri dishes. The air samples were obtained from six different male rooms. This was collected in duplicates with a nutrient agar normally utilized for bacteria isolation mixed with Griseofuvin, a strict exposure time of exactly 20minutes was observed. The plate was kept a meter above the floor level, away from the windows and the fan turned off. Thereafter the plates were transported to the laboratory and incubated at 37°C for 24- 48hrs. After incubation, the bacteria load was enumerated and discreet colonies with the help of a heat flamed wire loop were picked and streaked on the nutrient agar plate. The plates incubated at 37°C for 24hrs to obtain a pure culture which were further sub-cultured into nutrient agar slant in McCartney bottle as means of storage for further biochemical test.

Cultural and Biochemical Identification of the Bacteria

A visual observation of the shape, size, surface, colonies elevation of the bacteria on the plate containing culture

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was done. Following cultural characteristics, the isolates were subjected to the following test: Gram staining, Catalase test, Coagulase test, Oxidase test and potential pathogenicity testing.

RESULTS

Sampled Indoor Air Bacteria Concentration

The concentration of bacteria isolates increasement was directly proportional to the exposure time of the media. In July, the maximum bacteria concentration was seen in room 37 at 20min (21.5×10^2 CFU/m^3) and the minimum in room 49 at 20 min (0.02×10^2 CFU/m^3. The concentration of bacteria at other room 48 at 20 min (0.1×10^2 CFU/m^3), room 47 at 20 min (11.0×10^2 CFU/m\$^3$), room 38 at 20 min ($16.5 \times 10^2$ CFU/m^3), room 39 at 20 min (10.5×10^2 CFU/m^3) as seen in (Table 1), While for the month of November, the highest bacteria concentration was seen in room 37 at 20min (26.5×10^2 CFU/m^3) and the least at room 49 at 20 min (0.09×10^2 CFU/m^3). The concentration of bacteria at other room 48 at 20 min (0.3×10^2 CFU/m^3), room 47 at 20 min (13.5×10^2 CFU/m^3), room 38 at 20 min (19.2×10^2 CFM/M^3), room 39 at 20 min (15.1×10^2 CFU/m^3) as shown in (Table 2),

Table 1: The bacteria count and time of exposure of the six selected rooms in keystone (male) hostel for the month of July

Rooms	**Duration of Exposure (Min)**	**Bacteria concentration (CFU/M^3)**
Room 37 Room 38 Room 39 Room 47 Room 48 Room 49	20 20 20 20 20 20	21.5×10^2 16.5×10^2 10.5×10^2 11.0×10^2 0.1×10^2 0.02×10^2

KEY: Mins =Minutes, CFU = Colony Forming Units

Table 2: The bacteria count and time of exposure of the six selected rooms in keystone (male) hostel for the month of November

Rooms	**Duration of Exposure (Min)**	**Bacteria concentration (CFU/M^3)**
Room 37 Room 38 Room 39 Room 47 Room 48 Room 49	20 20 20 20 20 20	26.5×10^2 19.2×10^2 15.1×10^2 13.5×10^2 0.3×10^2 0.09×10^2

KEY: Mins =Minutes, CFU = Colony Forming Units

Bacteria Isolates' Morphology and Characterization

The bacteria isolates' identification results showed; *Staphylococcus aureus, Escherichia coli, Bacillus cerus, Streptococcus pyogenes, Klebsiella species, Serratia marcescens, Streptococcus pyogenes* (Table 3)

Table 3: Morphology and characterization of bacteria isolates

Isolates	**Morphology**	**Gram Reaction**	**Catalase**	**Oxidase**	**Coagulase**	**Suspected organisms**	**Level of occurrence**				**Frequency of occurrence of the bacteria**
A	Yellow pigment	+ (cocci)	+	-	+	*Staphylococcus aureus*	+	+	+	+	100%
B	Cloudy Pigment	-(Rod)	+	-	+	*Escherichia coli*	+	+	+	-	60%

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C	Pinky colour	+(Rod)	+	-	+	*Bacillus cerus*	+	-	-	-	30%
D	Milk Colour	+(Rod)	+	-	+	*Streptococcus pyogenes*	+	-	+	-	50%
E	Light Pink	-Rod	+	-	+	*Klebsiella spp*	+	-	+	-	50%
F	Red Pigment	-(Rod)	+	-	+	*Serratia marcescens*	+	-	-	-	30%
G	Cream	-(Rod)	+	-	+	*Proteus spp*	+	-	+	-	50%

KEY: A=All the rooms except 48 and 49, B= Rooms 37, 38, and 47 C=Room 38, D=Rooms 47 and 38 E=Room 38, 39, 47 and 37, F= Room 37 G= Rooms 47, 38, and 39

Testing the Isolates for Potential Pathogenicity

The test for potential pathogenicity showed that *Escherichia coli, Serratia marcescens and Klebsiella spp* were alpha hemolysis positive classifying them as semi potentially pathogenic, whereas bacteria like *Staphylococcus aureus, Bacillus cereus, Streptococcus pyogenes and proteus spp,* were beta hemolysis positive classifying them as potentially pathogenic bacteria species. (Table 4).

Table 4; Potential Pathogenicity testing of the isolates

Apha hemolysis	**Beta hemolysis**	**Gamma hemolysis**	**Suspected organism**
- + - + - - -	+ - + - + + +	- - - - - - -	*Staphylococcus aureus Escherichia coli Bacillus cerus Streptococcus pyogenes Klebsiella spp Serratia marcescens Proteus spp*

DISCUSSION

The knowledge of the indoor air bacteriological concentration is essential to estimating the quality of indoor air breathed in by individuals in a particular environment [4]. This research clearly stated that the amount and category of airborne microorganism indicates the state of an environment. In this study, we enumerated, isolated and identified the airborne bacteria from the male keystone hostel in University of Benin, Benin City. The concentration of the microorganism was seen on an increase in the month of November (dry season) in respect of the degrees of exposure. Tables 1 and 2. This aligns with [1] and contradicts [3], and [5], as the number bacteria isolates did not rise as result of short exposure time. The bacteria isolates' morphology and characterization in Table 3, which showed a total of seven species, *Staphylococcus aureus* (+ve)*, Escherichia coli* (-ve), *Bacillus cereus* (+ve), *Streptococcus pyogenes* (+ve)*, Klebsiella spp* (ve), *Sarratia marcescens* (-ve), *Proteus spp* (-ve) and in alignment with [6] and [7], However, they identified *Enterobacter aerogenes* and *proteus spp* respectively in their study, while [3] did not identify *proteus spp*. Bacteria isolates' frequency as revealed in Table 3 indicated that Staphylococcus aureus had the highest percentage of 100%, with *Escherichia coli* seconding at 60%, closely mark by *Klebbsiella spp, Streptococcus pyogenes* and *Proteus spp* with 50%, *Serratia marcescens* with 30%, *Bacillus cereus* being the least with 24%. This was acknowledged because of students' activities in the during exposure, which aligns [9] and [11] who recorded *Staphylococcus aureus* had highest frequency of 69% and *Serratia marcescens* the least at 8%. In contrast [10] and [12] recorded *Enterobacter spp* as the most occurring bacteria isolate.

Room 48 and 49 showed non-significant to bacterial load, in contrast to room 37, 38, 39, and 47 due to two students living in room 49 and 48, while six students each were the occupants of room 37, 38, 39, and 47, hinting a possible link between occupancy and microbial growth; thus, suggest that lower occupancy levels is ideal for a reduced microbial concentration in indoor spaces. [1] also supports these results, indicating human occupancy as a significant factor influencing the types and amounts of bioaerosols present in indoor settings, particularly in

buildings poor ventilation or high occupancy rates.

The bacteria isolates' Potential Pathogenicity as displayed in Table 4, indicates the beta hemolysis positive bacteria isolate were *Staphylococcus aureus, Bacillus cereus* and *Streptococcus pyogenes* automatically grading them as potentially pathogenic bacteria (disease causing bacteria), suggesting they were introduced into the air through the activities of human as in coughing and sneezing in the hostel and commercial industrialization.

CONCLUSION

A high bacterial load was found in room 37, 38, 39, and 47 with six occupants each in the University of Benin, keystone hostel in contrast with room 48 and 49 with two occupants each when compared with varying indoor air biological standards. Particulate matter concentration, overcrowding and poor sanitation were associated with the indoor bacterial load. Bacillus spp., Proteus spp., and Staphylococcus aureus were amongst the identified bacterial isolates in room 37, 38, 39 and 47. However, the result of the study revealed that *Staphylococcus aureus, Bacillus cereus* and *Streptococcus pyogenes* exhibited potential pathogenic characteristics, thus signifies that some rooms in keystone male hostel air quality could have health consequences which calls for a prompt health management practices.

RECOMMENDATION

It is recommended that proper health and environmental sanitation which includes a proper personal hygiene, in house and environment clean up of the hostel should be regularly done to improve the air quality in the hostel. Overcrowding should be avoided, student should keep to the rules of living singly per rooms or at least two persons per room in the hostel, in other to combat spread of diseases and improve proper ventilation system in various rooms as indicated in sterile indoor air quality of room 48 and 49. Finally, basic amenities should be always made available such as light and water so as to create a good platform for practicing a good hygienic lifestyle. These measures will enhance the hostels' indoor air quality, improve public health and minimize the risks of potential infectious diseases within our environment.

Competing Interests Authors have stated that there are no conflicting interests present.

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