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Bacteriological Assessment of the Indoor Air of a Private University in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author JCO designed the study, carried out the laboratory analyses of the study with author CPI. Author JCO performed the statistical analysis, wrote and proof-read the manuscript. Authors IN, CAI, CUU and AEN managed the literature searches and wrote the protocols. All authors thoroughly proof read and approved the final manuscript.

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ABSTRACT

The bacteriological assessment of indoor air of the male hostel at Rhema University Nigeria was undertaken in this study. Bacteriological analyses of Air samples from male hostels was carried out weekly for 4 weeks using standard microbiological methods in June, 2021 to determine their bacteriological content. Data obtained was analyzed using descriptive statistics and presented in tables. The result showed that the concentration of bacteria isolates increased as the duration of exposure of the media increased. The highest bacteria concentration was seen at room 205 at 40 minutes (29.8×10^2CFU/M^3) and the least at room 204 at 20 minutes (0.9×10^1 CFU/M^3). The concentration of bacteria at other rooms were room 305 at 40 minutes (17.7×10^2 CFU/M^3), room 304 at 20 minutes had 1.3×10^1 CFU/M^3, room 405 at 40 minutes had 17.8×10^2 CFU/M^3, room 404 at 20 minutes had 3.6×10^1 CFU/M^3, room 504 at 40 minutes had 17.6×10^2 CFU/M^3 and room 503 at 20 minutes had 11.9×10^2 CFU/M^3. A total of eleven (11) different bacteria species were

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isolated and identified as *Staphylococcus aureus* (100%), *Escherichia coli* (75%), *Staphylococcus epidermidis* (75%), *Klebsiella spp* (75%), *Bacillus subtilis* (75%), *Streptococcus pyogenes* (50%), *Bacillus megaterium* (50%), *Bacillus cereus* (50%) and *Serratia marcescens* (25%). *Staphylococcus aureus* is the most occurring bacteria specie (100%) while *Serratia marcescens* is the least occurring bacteria specie (25%). Potential pathogenicity testing of isolates revealed *Staphylococcus aureus, Bacillus cereus and Streptococcus pyogenes* as potential pathogenic species found in the hostel rooms. Bearing in mind that some of the bacteria species isolated showed potential pathogenic abilities, it means that the air quality of the male hostel rooms may have health implications. There is therefore need for periodic air quality evaluation in the male hostel to discover and manage those environmental variables which favours the multiplication of bacteria. Students are advised to implement good sanitation and hygiene practices to improve indoor air quality in the hostels and prevent possible infection or disease.

Keywords: Bacteriological; assessment; indoor air; hostel; Rhema University; Nigeria.

1. INTRODUCTION

The quality of air taken in by an individual within his environment can decide the health of that human being [1]. The quality of indoor air is not easily regulated and therefore can put human health in danger [2]. The major sources of indoor air contamination are inadequate ventilation and inappropriate management of the environment [3]. The transmission of pathogens by air could be through droplets with microbes from infected people and moved via the air which can be put on the host. Droplets are produced mostly when a person coughs and sneezes. Spore-forming bacteria are capable of surviving as bio-aerosols and stay viable under high humidity and suitable temperature in air for a long period [4]. Microorganisms present in the air can influence human health, causing numerous diseases transmitted through respiratory route [5]. The microbial contamination of indoor air is a function of the quality of air, the number of individuals in the place, the level of ventilation and activities such as sweeping and waving of cloths which leads to air-borne contamination [6]. Indoor air may contain a broad variety of pathogenic and non-pathogenic bacteria which might come from human beings [7]. Proficient measures are immediately required to fight the predicament of indoor air quality and some studies have shown the noteworthy dangers of global warming on human health due to increase in the level of indoor air pollution. Efforts to prevent indoor air acquired infections involves effective use of sterilization and disinfectants [8],which leads to reduced attention to indoor air variables that lead to air-borne infections [9]. This study is aimed at assessing the indoor air quality in the male hostel, Rhema University, Nigeria, Aba, Abia state.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Rhema University Aba, Abia State, Nigeria. Rhema University is a private tertiary institution, licensed and approved by the Federal Government of Nigeria. The institution is located in Aba, Abia State, in the South Eastern part of Nigeria. One (1) sampling location of Rhema University was used in this study that is the twenty (20) rooms of its Male hostel selected via simple random sampling. Each room has about four (4) occupants.

2.2 Sampling Procedure

Samples were taken in the twenty (20) male hostel rooms selected via simple random sampling from first floor to fourth floor. Passive monitoring, using the settle plate method was done by exposing the petri-dishes containing culture media at the different rooms examined in the hostel. Sampling was done in the evening at 9:00pm. Air samples were collected once a week for four weeks consecutively in the month of June, 2021. The plates containing nutrient agar (NA) was used for the isolation of bacteria and antifungal agent (Griseofulvin) was impregnated into the nutrient agar medium for the inhibition of fungi growth. Each plate was exposed on a table above ground level for a period of 20 minutes and 40minutes respectively for indoor air sampling. The bacterial culture plates were incubated at a temperature of 37^0C for 48hours in an incubator.

2.3 Microbiological Examination

After incubation, all the nutrient agar plates incubated at 37^0C for 48hours were observed,

and total number of bacterial colony forming units per cubic meter were counted and recorded. The colonial morphology of the colonies formed was noted; distinct and identical colonies were sub-cultured and incubated at 37^0C for 24 hours and stored for identification and characterization following the method of Bergey's Manual of Systematic Bacteriology [10]. The potential pathogenic testing of bacteria isolates were done according to [11].

2.4 Data Analysis

The data collected was pooled and analyzed with descriptive statistics and the resulting outputs were presented in tables.

3. RESULTS

3.1 Concentration of Bacteria in Sampled Indoor Air

The concentration of bacteria in sampled indoor air at week 1 showed that the higher the duration of exposure of the prepared culture media (20, 40minutes), the higher the concentration of the bacteria recorded. The highest bacteria concentration was observed in room 205 at 40minutes (29.8×10^2 CFU/M^3) whereas the least was in room 204 at 20 minutes 0.9×10^1 CFU/M^3 (Table 1). The concentration of the bacteria for the control was zero as it showed no bacterial growth at all.

The concentration of bacteria in sampled indoor air at week 2 showed that the higher the duration of exposure of the prepared culture media (20, 40minutes), the higher the concentration of the bacteria recorded. The highest bacteria concentration was seen at room 305 at 40minutes which was 17.7×10^2CFU/M^3 whereas the least was at room 304 at 20minutes which was 1.3×10^1 CFU/M^3 (Table 2). The concentration of the bacteria for the control was zero as it showed no bacterial growth at all.

The concentration of bacteria in sampled indoor air at week 3, showed that the higher the duration of exposure of the prepared culture media (20, 40minutes), the higher the concentration of the bacteria, The highest bacteria concentration was observed at room 405 at 40minutes (17.8×10^2CFU/M^3) and the least at room 404 at 20minutes (3.6×10^1CFU/M^3) as shown on Table 3. The concentration of the bacteria for the control was zero as it showed no bacterial growth at all.

The concentration of bacteria in sampled indoor air at week 4, showed that the higher the duration of exposure of the prepared culture media (20, 40minutes), the higher the concentration of the bacteria, The highest bacteria concentration was recorded at room 504 at 40 minutes (17.6×10^2CFU/M^3) and the least at room 503 at 20minutes (11.9×10^2CFU/M^3) as shown on Table 4. The concentration of the bacteria for the control was zero as it showed no bacterial growth at all.

Table 1. Concentration of bacteria in sampled indoor air at first floor rooms at week 1

Rooms	Duration of exposure/Bacterial concentration (CFU/M^3)	
	20 mins	**40 mins**
Room 201	5.2×10^1	11.2×10^2
Room 202	10×10^2	15.5×10^2
Room 203	7.8×10^1	18.9×10^2
Room 204	0.9×10^1	6.5×10^1
Room 205	14.7×10^2	29.8×10^2

KEY: *Mins = Minutes, CFU = Colony Forming Units*

Table 2. Concentration of bacteria in sampled indoor air in second floor rooms at week 2

Rooms	Duration of exposure/Bacterial concentration (CFU/M^3)	
	20 mins	**40 mins**
Room 301	8.4×10^1	11.7×10^1
Room 302	10.4×10^1	15.7×10^1
Room 303	4.7×10^1	7.1×10^1
Room 304	1.3×10^1	1.6×10^1
Room 305	13.7×10^2	17.7×10^2

KEY: *Mins =Minutes, CFU = Colony Forming Units*

Table 3. Concentration of bacteria in sampled indoor air in third floor rooms at week 3

Rooms	Duration of exposure/Bacterial concentration (CFU/M^3)	
	20 Mins	**40 Mins**
Room 401	8.6 x 10^1	10.4 x 10^2
Room 402	13.0 x 10^1	13.3 x 10^2
Room 403	8.9 x 10^1	9.2 x 10^1
Room404	3.6 x 10^1	3.9 x 10^1
Room 405	16.0 x 10^2	17.8 x 10^2

KEY: *Mins =Minutes, CFU = Colony Forming Units*

Table 4. Concentration of bacteria in sampled indoor air in fourth floor rooms at week 4

Rooms	Duration of exposure/Bacterial concentration (CFU/M^3)	
	20 mins	**40 mins**
Room 501	13.5 x 10^2	14.0 x 10^2
Room 502	12.7 x 10^2	14.7 x 10^2
Room 503	11.9 x 10^2	13.6 x 10^2
Room 505	13.6 x 10^2	17.5 x 10^2

KEY: *Mins =Minutes, CFU = Colony Forming Units*

Table 5. Morphology and characterization of bacteria isolates

Isolates	Morphology/ Pigmentation	Gram Positive or Negative	Catalase test	Oxidase test	Coagulase test	Suspected organism
A	Yellow pigment	**+** (Coccus)	**+**	**-**	**+**	*Staphylococcus aureus*
B	bright yellow pigment	**+** (Coccus)	**+**	**+**	**+**	*Micrococcus luteus*
C	Cloudy pigment	**-(** Rod)	**+**	**-**	**+**	*Escherichia coli*
D	Pink pigment	**+(** Rod)	**+**	**-**	**+**	*Bacillus cereus*
E	Milk colour pigment	**+** (Coccus)	**-**	**-**	**+**	*Streptococcus pyogenes*
F	Smooth and milk white pigment	**+(** Rod)	**+**	**-**	**+**	*Bacillus megaterium*
G	White pigment	**+** (Coccus)	**+**	**-**	**-**	*Staphylococcus epidermidis*
H	Light pink pigment	**-(** Rod)	**+**	**-**	**+**	*Klebsiella spp*
I	Gray-white pigment	**+(** Rod)	**+**	**+**	**+**	*Bacillus subtilis*
J	Red pigment	**-** (Rod)	**+**	**-**	**+**	*Serratia marcescens*
K	Milk colour pigment	**+** (Coccus)	**-**	**-**	**+**	*Streptococcus pyogenes*

KEY:A= *Room 201 (20 minutes),* ***B=*** *Room 201 (40 minutes),* ***C=*** *Room 305****, D=*** *Room 201 (20 minutes)* ***, E=*** *Room 202 (40minutes)* ***, F=*** *Room 203 (20minutes)* ***, G=*** *Room303****, H=*** *Room 203****, I=*** *Room 205* ***, J=****Room 302* ***, K=****Room 202 (40 minutes).*

3.2 Morphology and Characterization of Bacteria Isolates

The result of the identification of the bacteria isolates revealed the following isolates *Staphylococcus aureus, Micrococcus luteus, Escherichia coli, Bacillus cerus, Streptococcus pyogenes, Staphylococcus epidermidis, Klebsiella species, Bacillus subtilis, Serratia marcescens, Streptococcus pyogenes and Streptococcus specie* (Table 5).

Table 6. Frequency of occurrence of Bacteria Isolate from each sampled site

Bacteria Isolate	A	B	C	D	% frequency of occurrence
Staphylococcus aureus	+	+	+	+	100%
Micrococcus luteus	+	+	-	-	50%
Escherichia coli	+	+	+	-	75%
Bacillus cereus	+	-	+	-	50%
Streptococcus pyogenes	+	-	+	-	50%
Bacillus megaterium	+	-	-	+	50%
Staphylococcus epidermidis	+	+	+	-	75%
Klebsiella spp	+	+	+	-	75%
Bacillus subtilis	+	+	-	+	75%
Serratia marcescens	-	-	+	-	25%
Streptococcus pyogenes	+	-	+	-	50%

***Key: A=** Level 1, **B**= Level 2, **C**= Level 3, **D**= Level 4. **%=** percentage of occurrence.*

Table 7. Potential Pathogenicity testing of the isolates

Rooms	Alpha hemolysis	Beta hemolysis	Gamma hemolysis	Suspected organism
A	-	+	-	*Staphylococcus aureus*
B	+	-	-	*Micrococcus luteus*
C	+	-	-	*Escherichia coli*
D	-	+	-	*Bacillus cereus*
E	-	+	-	*Streptococcus pyogenes*
F	-	-	+	*Bacillus megaterium*
G	-	-	+	*Staphylococcus epidermidis*
H	+	-	-	*Klebsiella spp*
I	-	-	+	*Bacillus subtilis*
J	-	+	-	*Serratia marcescens*
K	-	+	-	*Streptococcus pyogenes*

***KEY:** **A=** Room 201, **B=** Room 201 (40 minutes), **C=** Room 305**, D=** Room 201 (20 minutes) **, E=** Room 202 (40minutes) **, F=** Room 203 (20minutes) **, G=** Room303**, H=** Room 203**, I=** Room 205 **, J=**Room 302 **, K=**Room 202 (40 minutes).*

3.3 Frequency of Occurrence of Bacteria Isolate

The frequency of occurrence of the bacteria isolate showed that *Staphylococcus aureus* had the highest frequency of 100%, followed by *Escherichia coli, Staphylococcus epidermidis, Klebbsiella spp and Bacillus subtilis,* which had the same frequency of 75% whereas *Streptococcus pyogenes, Bacillus megaterium and Bacillus cereus* had equal frequency of 50%. The bacteria isolates with the lowest frequency was *Serratia marcescens* (25%) (Table 6).

3.4 Potential Pathogenicity Testing of the Isolates

The potential pathogenicity test revealed that *Micrococcus luteus, Escherichia coli, Serratia marcescens and Klebsiella* were alpha hemolysis positive making them semi potentially pathogenic, other bacteria species like the *Staphylococcus aureus, Bacillus cereus, Streptococcus pyogenes,* were beta hemolysis positive making them potentially pathogenic bacteria species. *Bacillus megaterium, Bacillus epidermidis and Bacillus subtilis were Gamma hemolysis positive*, making them potentially harmless bacteria (Table 7).

4. DISCUSSION

The knowledge of the bacteriological concentration of indoor air is essential to checking the quality of indoor air. [12] reported that the number and type of air-borne microorganism is a pointer to the degree of cleanliness of an environment. In this present study, the higher the duration of exposure media, the higher the bacteria concentration, Tables 1-4. This is in agreement with [1] and disagrees with [13], and [12], as their concentration of bacteria isolates did not increase due to time exposure. The Morphology and characterization of bacteria

isolates as shown in Table 5 revealed a total of eleven (11) bacteria species, *Staphylococcus aureus* (+ve), *Micrococcus luteus* (+ve), *Escherichia coli* (-ve), *Bacillus cereus* (+ve), *Streptococcus pyogenes* (+ve), *Bacillus megaterium* (+ve), *Staphylococcus epidermidis (+ve), Klebsiella spp (-ve), Bacillus subtilis (+ve), Sarratia marcescens*(-ve), *Streptococcus pyogenes*(+ve), and this is in agreement with [12] and [13], except that in their study they identified *Enterobacter aerogenes* and *proteus mirabilis* respectively, while [6] did not identify *Sarratia marcescens.* This present work is also in agreement with [1], who identified similar bacteria species as was seen in this work. The frequency of occurrence of the Bacteria isolate as shown in Table 6 revealed that *Staphylococcus aureus* had the highest frequency of 100%, followed by *Escherichia coli, Staphylococcus epidermidis, Klebbsiella spp and Bacillus subtilis,* which had the frequency of 75%. *Streptococcus pyogenes, Bacillus megaterium and Bacillus cereus* had equal frequency of 50% whereas the lowest frequency was observed in *Serratia marcescens* (25%). This is believed to be due to the activities of the students in the room during exposure and this is in agreement with [13] who reported *Staphylococcus aureus* to have the highest frequency of 27% and the least frequency of 4% to *Serratia marcescens.* This work disagrees with [6] who reported *Enterobacter aerogenes* as the highest occurring bacteria isolates. The Potential Pathogenicity of the bacteria isolates shown in Table 7, revealed that *Staphylococcus aureus, Bacillus cereus* and *Streptococcus pyogenes,* were beta hemolysis positive making them potentialy pathogenic bacteria. These bacteria could have been introduced into the air via human activities in the hostel such as coughing and sneezing.

5. CONCLUSION

Bearing in mind that some of the bacteria species isolated showed potential pathogenic abilities, it means that the air quality of the male hostel rooms may have health implications.

6. RECOMMENDATIONS

There is need for periodic air quality evaluation in the male hostel to discover and manage those environmental variables which favours the multiplication of bacteria for health reasons. Students are advised to implement good sanitation and hygiene practices to improve indoor air quality in the hostels and prevent possible infection or disease.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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