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Microbiological assessment of indoor air quality of science laboratories in Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria

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Abstract

Laboratories are rooms equipped for performing scientific researches. Monitoring of bio-aerosols in laboratories will help to estimate the health hazards posed by airborne microorganisms and create standards for air quality control. This study was aimed at assessing the airborne bacteria present in the indoor environment of science laboratories in Olabisi Onabanjo University, Ago-Iwoye, Nigeria. Air samples were taken twice a day: in the morning and evening using the settle plate technique. Mean bacterial counts ranged from 236.6 CFU/m^3 to 1530.0 CFU/m^3. The highest mean bacterial count (1530.0 CFU/m^3) was obtained at the Microbiology laboratory while the least count (236.6 CFU/m^3) was obtained at the Physics laboratory. The bacterial count in the Microbiology laboratory was significantly higher than those obtained in the other labs ($p< 0.05$) There was no significant difference in the bacterial counts obtained in the morning and the evening ($p>0.05$). The levels of pollution with bacterial aerosols in the laboratories ranged from intermediate to high. Four bacterial species were identified, with *Bacillus species* (33%) being the most frequently isolated followed by *Staphylococcus aureus* (27%), *Micrococcus spp* (23%) while the least isolated organism was *Pseudomonas spp* (17%). The level of bacterial contamination observed in these laboratories calls for adequate sanitary measures to be put in place to control airborne bio-aerosols to safeguard the health of the users.

Keywords: Microbiological assessment, Indoor air quality, Bacteria, Science laboratories

1. Introduction

Most people in urban areas spend about 90% of their time indoors [1]. It has been also reported that many people spend most of their lives in different indoor environments of homes, care facilities, schools and workplaces [2]. Health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being [3]. Globally, an estimate of 3.8 million deaths was attributed to indoor air pollution in 2016 [4,5] and the level of indoor pollutants is said to be 2–5 times more than that of outdoor pollutants [6]. It has also been reported that poor air quality is associated with lungs and heart diseases [7]. Clean air is, therefore, a basic requirement of life and the quality of indoor air of homes, offices, schools, daycare centers and public buildings.

The presence of microorganisms which include bacteria, moulds and viruses is one of the problems encountered in indoor environments [8,9]. It has been reported that long exposure to microbial contaminated indoor air poses a threat to human health [10]. These microorganisms in the air are known as bioaerosols; colloidal suspensions of liquid droplets containing viruses, fungal spores and conidia, bacterial endospores, plant pollen and fragments of plant tissues [11,12]. They account for 5-34% of indoor air pollution in many environments [5]. The presence of bioaerosols in indoor air can compromise normal human activities, which necessitate frequent and efficient monitoring in homes, laboratories, offices and other environments [13]. The microbial quality of indoor air of any given place is determined by the quality of air entering the place, ventilation of the place, the number of occupants in the place, their physical activities and the amount aerosol generated.

Laboratories are rooms specially equipped for performing scientific researches. They are storehouses of mostly cellulosic and rarely non-cellulosic materials [14]. The different materials, chemicals, physical parameters of different environments in the laboratories as well as research activities taking place in these laboratories may contribute to the pollution of indoor air environment of laboratories [15]. Monitoring of bioaerosols in laboratories will enhance epidemiological investigation of infectious diseases, research into airborne microorganism spread and control, monitoring biohazardous procedures and can be employed as a quality control measure to determine the quality of indoor air [16]. This study was therefore aimed at assessing the airborne bacteria present in the indoor environment of

science laboratories and the possible hazards they can cause to laboratory staff and students working in the laboratories.

2. Materials and Methods

2.1 Study Area

Olabisi Onabanjo University is a state-owned university located in Ago-Iwoye, Ogun State, Nigeria. The institutions main campus, located in Ago-Iwoye, lies between Latitude 6.942359 ºN and Longitude 3.921554 ºN. It comprises six faculties which are: Faculty of Science, Faculty of Arts, Faculty of Law, Faculty of Social Sciences, Faculty of Administration and Management Sciences and Faculty of Education. The study was carried out in the Faculty of Science. Four major laboratories in the Faculty were selected for the study. They were Microbiology laboratory, Chemistry laboratory, Physics laboratory and Zoology and Environmental Biology laboratory

2.2 Collection of Air Samples

The settle plate method was used to collect indoor air samples from the four selected laboratories. Sampling was done at two regular intervals of a day. The first set of petri dishes were exposed before the commencement of bench work in the morning by 9.00 a.m. when the number of staff and students were minimal while the second sets of petri-dishes were exposed to air in the afternoon by 4.00 pm when the day's work was done and staff and students were about leaving the laboratory [17]. 90 mm diameter petri dishes containing 20 ml of sterile nutrient agar prepared in triplicates were exposed to indoor air in the different laboratories for thirty minutes after which the plates were covered and transported to the Department of Microbiology laboratory and incubated at 37 ºC for 24-48 h.

2.3 Enumeration of Bacteria

The colonies formed on petri dishes were enumerated and converted to colony-forming units per cubic meter of air (CFU/m^3) using the equation described by Omeliansky [9].

$N=5a \times 104 (bt) -1$

Where:

$N=CFU/m^3$of air

a= number of colonies on the petri dish

b=Surface area of the petri dish (cm^2)

t= Exposure time (mins).

2.4 Identification of Bacterial isolates

Bacteria isolates were characterized to genus level based on morphological, cellular and biochemical characteristics as described by Bergey's manual of determinative bacteriology. [18].

2.5 Statistical Analysis

The data generated in this study were subjected to One-way analysis of Variance (ANOVA) and Paired-Samples T-test using SPSS version 16.0 software to test the significant variation in bacterial concentration in the different laboratories at different sampling times. P-values <0.05 were considered significant.

3. Results and Discussion

The mean bacterial counts in the indoor air environment of the laboratories as presented in Table 3.1 ranged from 236.6 CFU/m^3 to 1530.0 CFU/m^3. The highest bacterial count (1530.0 CFU/m^3) was recorded at the Microbiology laboratory and the lowest bacterial count (236.6 CFU/m3) was obtained at the Physics laboratory. The mean bacterial count in the Microbiology lab was significantly ($p<0.05$) higher than those obtained from the other laboratories. Aneibo et al. [19] discovered more heterotrophic bacterial counts in Microbiology major laboratory compared to Animal and Environmental Biology main laboratories. Other researchers had also recorded higher bacterial counts in microbiology and Biology laboratories compared to Chemistry and Physics laboratories [20, 21].

Table 3.1: Mean bacterial counts of indoor air environment of science laboratories in Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

LAB	N	Mean CFU/m^3	Std. Deviation	Minimum CFU/m^3	Maximum CFU/m^3
MCB	4	1530.0	1358.6	388.0	3498.0
ZEB	4	327.3	72.9	242.0	388.0
PHY	4	236.6	93.9	145.0	364.0
CHM	4	254.5	127.9	145.0	437.0

Key: MCB= Microbiology**,** CHM= Chemistry**,** ZEB=Zoology and Environmental Biology**,** PHY= Physics.

Bacterial counts were higher in the evening compared with counts obtained in the morning in all the laboratories sampled. This finding corroborates that of other researchers that there are higher concentrations of bacteria in the afternoon or evening when students are actively working or about to leave the laboratories compared to the morning period [19-22]. However, there was no significant difference ($p>0.05$) between the counts obtained in the morning and those recorded in the evening (Figure 3.1). Aniebo et al. [19] also reported that the bacterial counts obtained in some major science laboratories in IBB University Lapai, Nigeria in the morning and evening were insignificant.

Table 3.2: Evaluation of the indoor air quality of the selected laboratories in accordance with sanitary standards for non-industrial premises

Sampling sites (LAB)	Bacterial concentration										
	Sampling time	8 am					4 pm				
	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	Very low	Low	Intermediate	High	Very high	Very low	Low	Intermediate	High	Very high
MCB		-	-	-	√		-	-	-	√	-
ZEB		-	-	√	-	-	-	-	√	-	-
PHY		-	-	√	-	-	-	-	√	-	-
CHM		-	-	√	-	-	-	-	√	-	-

NB: < 500 CFU/m^3 is permissible standard, (√) is the range and (-) not in the range.
Key**:** MCB= Microbiology**,** CHM= Chemistry**,** ZEB=Zoology and Environmental Biology**,** PHY= Physics

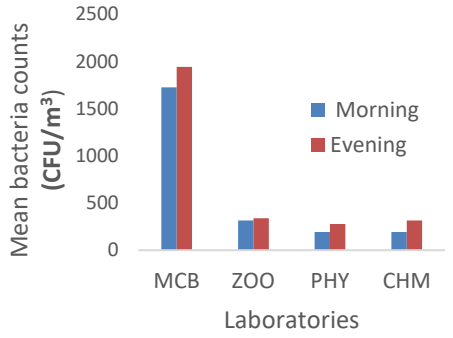

Figure 3.1: Mean bacterial counts at different sampling times in science laboratories in Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Key: MCB= Microbiology**,** CHM= Chemistry**,** ZEB=Zoology and Environmental Biology**,** PHY= Physics

Evaluation of the air quality of the selected laboratories following sanitary standards for non-industrial premises showed that Microbiology laboratory, which had the highest bacterial count (1530.0 CFU/m^3) could be rated as highly polluted while the levels of pollution in the other laboratories were intermediate (Table 3.2). There is no uniform universally international standard available on the acceptable maximum bioaerosol levels in the indoor air environment [23]. However, WHO has set a guideline at 500cfu/m^3 and if higher than this, the environment is considered polluted or contaminated [24]. Also, sanitary standards for non-industrial premises set by the European Commission in 1993 show that the high bacterial count in the Microbiology lab, which exceeded the 500 CFU/m^3 permissible level for non-industrial premises categorized the laboratory as polluted and dangerous to the staff and students of the department. The level of contamination in this laboratory was attributed to the various researches carried out which usually involve microorganisms as well as the high level of occupancy during the sampling periods. The level of pollution in the remaining laboratories was rated intermediate and considered relatively safe; however, measures should be put in place to reduce the bacterial loads to low levels and to prevent increase in the bacterial loads in these laboratories.

In total, four (4) bacteria were isolated and identified. They included *Bacillus spp*, *Staphylococcus aureus*, *Micrococcus spp* and *Pseudomonas spp*. The frequencies and percentages of occurrence of the isolated bacteria are presented in Figure 3.2. *Bacillus species* (33%) was the most isolated bacteria followed by *Staphylococcus aureus* (27%), *Micrococcus* (23%), while the least isolated bacteria was *Pseudomonas* species (17%). The distribution of the bacteria isolated in the laboratories is presented in Table 3.3. The highest number of bacterial isolates was obtained from the Microbiology laboratory while the least number of isolates was obtained from the Zoology laboratory. These organisms are among the most commonly isolated bacteria in indoor air environments [9, 25, 19-22].

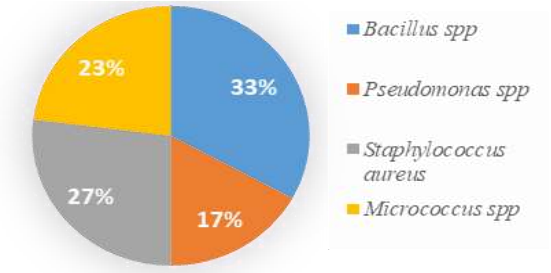

Figure 3.2: Frequencies and percentages of occurrence of the isolated from indoor air environment of science laboratories in Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Gram-positive bacteria formed 83% of the organisms isolated while only 17% were Gram-negative (Fig 3.2). This result showed the dominance of Gram-positive bacteria in the indoor air of the science laboratories as reported in other related studies [19, 22, 26]. Also, as seen in Figure 3.2, *Bacillus spp* and *Staphylococcus aureus* were found to be highly dominant in the air environments of the laboratories sampled. These organisms are commonly found in air, soil and water. Aniebo et al. [19] also reported *Bacillus* species as the dominant bacteria in the indoor air of a Microbiology laboratory. *Bacillus* species are persistent and dominant in different environments because of their ability to produce spores which allow the organisms to withstand unfavorable conditions and partly also because they are present in high numbers in the air [19, 27]. *Staphylococcus* is saprophytic in nature and generally associated with the human skin, which however given favorable conditions and environment can become opportunistic pathogens to man. *Staphylococcus aureus* can cause skin infections, septicemia and some gastrointestinal infections. The presence of these organisms in the indoor air also suggests contamination by human presence and activities.

Table 3.3: Distribution of bacteria isolated from indoor air environment of science laboratories in Olabisi Onabanjo University, Ago-Iwoye

Sampling Sites (Lab)	*Pseudomonas* spp	*Staphylococcus aureus*	*Bacillus* spp	*Micrococcus* spp
MCB	+	+	+	-
ZEB	-	-	+	+
PHY	+	+	+	-
CHM	-	+	-	+

Key: MCB= Microbiology, CHM= Chemistry, ZEB=Zoology and Environmental Biology, PHY= Physics.

4. Conclusion

This research has shown the presence of bacterial aerosols in the indoor air of all the laboratories sampled. Microbiology laboratory was found to be highly contaminated with bacterial aerosols compared with the other laboratories and evaluated as polluted. The bacteria isolated from these laboratories are opportunistic pathogens which can cause adverse health challenges, especially in individuals with compromised immune systems. Bacteria in the air of these laboratories can also contaminate various research works carried out by students which can render the works invalid or give false results resulting in serious hazards to the public. The use of nose masks while working in laboratories, adequate sanitary practices, as well as regular fumigation of science laboratories, can help to reduce the level of bioaerosols and the risks associated with these bioaerosols in the laboratories.

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