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Bioaerosol Assessment of Selected Offices within a Polytechnic

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: Microorganisms are ubiquitous in the built environment and their presence has been documented to have adverse effect on the users of such buildings. This study was conducted to assess the Bioaerosol concentrations of selected offices.
Study Design: A random sampling technique was adopted to select the eight (8) offices for the study based on accessibility and visitation.
Place and Duration of Study: The study was carried out in selected offices within Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt.
Methodology: Sedimentation technique was employed for the assessment involving Nutrient Agar, Mac Conkey Agar and Potato Dextrose Agar. The analysis was replicated thrice for both morning and afternoon sessions
Results: The results reveal that the mean total heterotrophic bacterial counts ranged from 5.85 x 10^3cfu/m^3 (SUG Office) to 3.80 x 10^4 cfu/m^3 (Lecturer Office 2) for the morning session while the afternoon session ranged from 1.13 x 10^4 cfu/m^3 (SUG Office) to 6.54 x 10^4 cfu/m^3 (Lecturer Office 2). The mean total coliform counts for the morning session ranged from 1.17 x 10^4 cfu/m^3 (ICE Office) to 4.07 x 10^4 cfu/m^3 (Lecturer Office 2) while the afternoon session ranged from 7.87 x 10^3 cfu/m^3 (Admission Office) to 2.40 x 10^4 cfu/m^3 (DSA Office). The mean total fungal counts ranged

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from 1.24 x 10^4 cfu/m^3 (DSA Office) to 3.91 x 10^4 cfu/m^3 (CSO Office) for the morning session while the afternoon session ranged from 8.87 x 10^3 cfu/m^3 (CSO office) to 5.13 x 10^4 cfu/m^3 (Lecturer Office 2).

Conclusion: This shows that the selected offices in Captain Elechi Amadi Polytechnic are being affected by the airborne bacteria and fungi higher than the recommended limit of 10^3 cfu/m^3. This can result in health challenges of the staff and students thereby reducing productivity, hence a need to control factors that increase the presence of bioaerosols and ensure good sanitary practices in offices.

Keywords: Air quality; bacteria; bioaerosol; fungi; office; polytechnic.

1. INTRODUCTION

Environmental regulators have increased interest in indoor air quality (IAQ) due to their concern in improving comfort, healthiness as well as the wellbeing of occupants of buildings [1]. Since people spend about 80–90% of their day in indoor environments, of which 25% is spent at work, for many, the health risks from exposure to indoor air pollution may be greater than those related to outdoor pollution [2]. Many factors affect indoor air pollution levels such as maintenance activities, the presence of contaminant sources (e.g. building materials, furnishings and equipment), the levels of contamination outdoors, the season, and indoor humidity and temperature, and ventilation rates. Concentrations of specific contaminants in indoor air can often be considerably higher than concentration levels outdoors [3]. Indoor contaminates include formaldehyde, volatile organic compounds (VOCs), particles, pesticides, radon, fungi, bacteria, and nitrogen oxides and production of volatile emissions by fungi [4]. Poorly operating Heating, Ventilation and Air Conditioning (HVAC) systems can cause indoor air pollutants and carbon dioxide to become concentrated to levels that are harmful to humans. HVAC systems that do not effectively control relative humidity can promote the growth of bacteria and mould. Moisture, dirt, bacteria and build-up of other harmful contaminants in HVAC systems also degrade the quality of the air [3]. Often, the presence of both indoor contaminants and other indoor environmental factors makes it difficult to identify direct causes of occupant discomfort and health symptoms.

According to Lal, et al. [5], bioaerosol is the term that is often used for airborne particles that mostly originate from different biological materials. Inhalation, ingestion, and dermal contact, out of which inhalation is most predominantly, are the various routes through which human are exposed to bioaerosol. Airborne bacteria and fungi are the most studied bioaerosols and are responsible for the biological contamination of indoor environments [6]. Therefore, the characterization of bioaerosol levels in both indoor and outdoor environments have become an important issue due to their adverse health effects [7]. Microorganisms are known to be ubiquitous in the atmosphere but their concentrations are significantly affected by specific environmental factors [8]. High concentrations of microorganisms in the air can be toxic; however, some microorganisms can cause serious diseases even at low concentrations [6]. These microorganisms are still able to reach their new hosts through the air for survival, even when various conditions such as ultra-violet (UV) light, relative humidity and dryness, temperature, play a major role in controlling the growth of microbes from growing in unfavorable environments [9].

Bioaerosols have been shown to cause about 30% of health problems related to indoor air quality, and can breed allergies, SBS symptoms (“sick building syndrome”); dermatosis and respiratory diseases [10]. Actually, almost 30% of office workers complain of health problems, linking them with poor Indoor Air Quality (IAQ) [11]. Exposure to biological agents in the work environment is associated with a wide range of health effects, including three major groups of diseases: infections, toxic and allergic reactions [12]. Employees in office buildings often share a small space containing a wide spectrum of microorganisms. Human skin, mouths, and nasal cavities contain billions of microorganisms, which can then accumulate in offices. Soil microbes from plants can also be breathed in by office workers or can be transferred to dust particles from the outdoor air [13].

Since airborne microorganisms mostly fall into respirable size range (with diameter < 10 µm), they usually have the capability to penetrate deep down into human lungs causing several

health hazards [14,15]. Hence, their presence in indoor environments is often associated with sick building syndrome (SBS) [16]. Previous research has indicated that human occupancy increases the airborne bacterial load and leaves a distinctly human microbial signal inside buildings [7,17]. Therefore, the study aim to assess bioaerosols quality in selected offices of within Captain Elechi Amadi Polytechnic, Rumuola.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Captain Elechi Amadi Polytechnic Rumuola, Obio-Akpor Local Government Area, Rivers State. Some parts of Obio-Akpor Local Government Area including Rumuola is considered to be an extension of Port Harcourt metropolis, one of the major centres of economic activities in Nigeria, and one of the major cities of the Niger Delta, located in Rivers State. It is located between latitudes 4°45'N and 4°60'N and longitudes 6°50'E and 8°00'E.The Local Government Area covers 260 km^2 and at the 2006 Census held a population of 464,789.

2.2 Sampling Stations

The Sampling design used for choosing the sample locations and points was the purposive sampling method. These locations were chosen for the study considering the human activities in the offices. The sampling stations which are some selected in the Polytechnic include the Chief Security Officer's office (CSO), Science Laboratory Technology Department office, Admission office, Institute of Continuing Education Office, Director of Students Affairs office, Student Union Government Secretariat, Lecture Office 1 and Lecturer Office 2.

Lecture office 1 is a medium sized office with one window, a door and ceiling fan for ventilation. Lecture office 2 is a medium sized office with one window, a door and a ceiling fan for ventilation; the office also has an open roof where mucor growth could be seen. Chief Security Officer's office (CSO) is a small two-room office with no window but with a small standing fan for ventilation. Science Laboratory Technology (SLT) Department office is a medium sized office with one window, a door and ceiling fan for ventilation. The office is occupied with files and envelopes. Admission office is a large office with four tables for staff, a window, a door and a ceiling fan. ICE office is a large office with one table, a door and a fan. The office is occupied with lots of files and envelopes with dust on it. Directorate of Students Affairs (DSA) office is a large office with one door, one window, 2 tables for staff, a table and upholstery for visitors while the Student Union Government (SUG) office is a medium sized office with one window and a table. All the sampled offices are located within bungalow buildings, having ceramic tiled floors, windows and doors open always and are closed to flowers planted outside.

2.3 Sampling and Microbiological Analysis

The microbiological air quality in the selected offices of within the Polytechnic was assessed employing settle plate culture technique, also known as sedimentation technique. This is based on deposition of viable particles (bioaerosols) on the surface of a solid medium per a given exposure time. For the enumeration of total heterotrophic bacterial count, total coliform and total heterotrophic fungal counts in air within the selected offices, freshly prepared Nutrient Agar (NA), MacConkey Agar (MA) and Potato Dextrose Agar (PDA) plates respectively in duplicate medium were exposed to air for thirty minutes [18]. All the bioaerosols sampling was done at a height of 1.5 m above the ground level to stimulate the human breathing zone and the corner of the rooms away from the windows and doors to minimize interrupting office work. The sample collection was done in two regular intervals of a day; that is the Petri-dishes containing Nutrient Agar, MacConkey Agar and Potato Dextrose Agar, were exposed within the selected offices exposed at 10 – 10:30 am for the morning session and repeated at 2 – 2:30 pm for afternoon session [8,18]. This procedure was repeated thrice each month between August and October, 2019, which is also a rainy season in Nigeria. The Nutrient Agar and MacConkey Agar culture plates for total heterotrophic bacterial count and total coliform counts respectively were incubated at 37°C for 24-48 hours. The Potato Dextrose Agar culture plates for total heterotrophic fungal counts were then incubated at 37°C for 3-4 days.

2.4 Estimation of Bioaerosol

The average of colony forming units (cfu) of fungi was calculated and converted to organisms per cubic meter of air [19].

Cfu/m^3 = a 1000 /p.t.0.2

Where

a = the number of colonies on the petri dishes (plates)
p = surface of the petri dishes (plates) (mm)
t = the time of petri dishes (plates) exposure (minutes)

2.5 Data Analysis

Data generated from the work was analyzed using descriptive statistics (means) and presented in Tables.

3. RESULTS

The mean total heterotrophic bacterial and fungal counts in air within selected offices in Captain Elechi Amadi Polytechnic were assessed and the results obtained after triplicate sampling are presented in Tables 1, 2 and 3. During the analysis for the morning session, the mean total bacterial count in the air within the selected offices in the ascending order was 5.85 x 10^3 cfu/m^3 (SUG Office) > 9.70 x10^3 cfu/m^3 (Lecturer Office 1) > 9.94 x 10^3 cfu/m^3 (DSA Office) > 1.03 x 10^4 cfu/m^3 (ICE Office) > 1.18 x $10^4$$cfu/m^3$ (CSO Office) > 1.20 x 10^4 cfu/m^3 (SLT Dept Office) > 1.49 x 10^4 cfu/m^3 (Admission Office) > 3.80 x10^4 cfu/m^3 (Lecturer Office 2) while the afternoon session ranged from 1.13 x 10^4 cfu/m^3 (SUG Office) > 1.43 x10^4 cfu/m^3 (ICE Office) > 1.44 x10^4 cfu/m^3 (Lecturer Office 1) > 1.46 x10^4 cfu/m^3 (DSA Office) > 1.84 x10^4 cfu/m^3 (CSO Office) > 1.89 x10^4 cfu/m^3 (SLT Dept Office) > 2.32 x10^4 cfu/m^3 (Admission Office) > 6.54 x 10^4 cfu/m^3 (Lecturer Office 2) (Table 1).

The mean total coliform counts in the air within the selected office for the morning session is in the ascending order of 1.17 x 10^4 cfu/m^3 (ICE office) > 1.43 x10^4 cfu/m^3 (Lecturer Office 1) > 1.47 x10^4 cfu/m^3 (SLT Dept. Office) > 1.53 x 10^4 cfu/m^3 (Admission Office) > 1.57 x 10^4 cfu/m^3 (DSA Office) > 2.17 x10^4 cfu/m^3 (SUG Office) > 3.17 x10^4 cfu/m^3 (CSO Office) > 4.07 x 10^4 cfu/m^3 (Lecturer Office 2) while the afternoon session reveal an ascending order of 7.87 x 10^3 cfu/m^3 (Admission Office) > 8.57 x 10^3 cfu/m^3 (SUG Office) > 1.05 x 10^3 cfu/m^3 (ICE Office) >1.47 x 10^4 cfu/m^3 (Lecturer Office 2) > 1.53 x 10^4 cfu/m^3 (Lecturer Office 1) > 1.64 x 10^4 cfu/m^3 (CSO Office) > 2.00 x 10^4 cfu/m^3 (SLT Office) > 2.40 x 10^4 cfu/m^3 (DSA Office) (Table 2).

The mean total fungal counts in the air within the selected offices in the ascending order was 1.24 x 10^4 cfu/m^3 (DSA Office) > 1.35 x10^4 cfu/m^3 (Lecturer Office 2) > 1.43 x 10^4 cfu/m^3 (SUG Office) > 1.77 x 10^4 cfu/m^3 (ICE Office) > 2.48 x 10^4 cfu/m^3 (SLT Dept Office) > 2.84 x 10^4 cfu/m^3 (Admission Office) > 3.60 x 10^4 cfu/m^3 (Lecturer Office 1) > 3.91 x 10^4 cfu/m^3 (CSO Office) for the morning session while the afternoon session ranged from 8.87 x 10^3 cfu/m^3 (CSO office) > 1.15 x10^4 cfu/m^3 (Lecturer Office 1) > 1.50 x10^4 cfu/m^3 (SUG Office) > 1.58 x10^4 cfu/m^3 (ICE Office) > 1.84 x10^4 cfu/m^3 (DSA Office) > 2.80 x10^4 cfu/m^3 (SLT Dept Office) > 5.13 x 104 cfu/m^3 (Lecturer Office 2). Generally, the afternoon session recorded higher counts when compared to the morning session (Table 3).

Table 1. Mean total heterotrophic bacterial counts in air within selected offices in Captain Elechi Amadi Polytechnic, Rumuola

Sampling point	Session	
	Morning (cfu/m^3)	Afternoon (cfu/m^3)
Lecturer Office 1	9.70 x10^3	1.44 x10^4
Lecturer Office 2	3.80 x10^4	6.54 x10^4
SLT Dept Office	1.20 x10^4	1.89 x10^4
CSO Office	1.18 x10^4	1.84 x10^4
DSA Office	9.94 x10^3	1.46 x10^4
ICE Office	1.03 x10^4	1.43 x10^4
SUG Office	5.85 x10^3	1.13 x10^4
Admission Office	1.49 x10^4	2.32 x10^4

KEY: SLT Dept: Science Laboratory Technology Department; CSO: Chief Security Officer; DSA: Director of Students Affairs; ICE: Institute of Continuing Education; SUG: Student Union Government

Table 2. Mean total coliform counts in air within selected offices in Captain Elechi Amadi Polytechnic, Rumuola

Sampling point	Session	
	Morning (cfu/m^3)	Afternoon (cfu/m^3)
Lecturer Office 1	1.43 x10^4	1.53 x10^4
Lecturer Office 2	4.07 x10^4	1.47 x10^4
SLT Dept Office	1.47 x10^4	2.00 x10^4
CSO Office	3.70 x10^4	1.64 x10^4
DSA Office	1.57 x10^4	2.40 x10^4
ICE Office	1.17 x10^4	1.05 x10^4
SUG Office	2.17 x10^4	8.57 x10^3
Admission Office	1.53 x10^4	7.87 x10^3

KEY: SLT Dept: Science Laboratory Technology Department; CSO: Chief Security Officer; DSA: Director of Students Affairs; ICE: Institute of Continuing Education; SUG: Student Union Government

Table 3. Mean total fungal counts in air within selected offices in Captain Elechi Amadi Polytechnic, Rumuola

Sampling point	Session	
	Morning (cfu/m^3)	Afternoon (cfu/m^3)
Lecturer Office 1	3.60 x10^4	1.15 x10^4
Lecturer Office 2	1.35 x10^4	5.13 x10^4
SLT Dept Office	2.48 x10^4	2.80 x10^4
CSO Office	3.91 x10^4	8.87 x10^3
DSA Office	1.24 x10^4	1.84 x10^4
ICE Office	1.77 x10^4	1.58 x10^4
SUG Office	1.43 x10^4	1.50 x10^4
Admission Office	2.84 x10^4	2.53 x10^4

KEY: SLT Dept: Science Laboratory Technology Department; CSO: Chief Security Officer; DSA: Director of Students Affairs; ICE: Institute of Continuing Education; SUG: Student Union Government

4. DISCUSSION

Bioaerosols have potential allergenic or immunotoxic characteristics and are a probable cause of airborne infectious illnesses, especially in people with impaired or susceptible immune systems [6]. Therefore, knowledge about the prevalence of microflora in office and understanding the types of infections and allergies caused by aerosols is of utmost importance.

The findings of this study revealed that the mean total heterotrophic bacterial counts were higher than the average concentration of 424 cfu/m^3 to 821 cfu/m^3, culturable bacterial aerosol (CCBA) in building reported by Bragoszewska and Biedron [20] and the 61 cfu/m^3 reported by Sheik, et al. [21]. Generally, most of the sampled offices recorded counts which exceeds the recommended limit of 10^3cfu/m^3 suggested by National Institute of Occupational Safety and Health (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH) (500 cfu/m^3) [22] and Residential Limit Values (RLV) of 250 cfu/m^3 for bacterial concentrations [15]. The high counts recorded in offices such as Admission office, CSO office, SLT Departmental Office and Lecturer Office 2 could be explained due to the fact the number of student who visited these offices. During the study, admission was going on within the Polytechnic, hence the human presence. Lecturer Office 2 has defects such as leaking roof and growth of mucor on the ceiling. Once these occupants and visitors can be one of the natural sources of airborne microorganisms, it can also be expected that the total heterotrophs counting tend to present higher values when a greater number, or even an excess of people, is inside this environment. Such assumptions could lead again to the possibility of considering the total heterotrophic microorganisms as biological indicators of adverse situations for the indoor air quality [23].

The bacteria counts were significantly higher in the afternoon than morning and this might be as a result of the height of office activities as well as

higher humidity levels in the afternoon since it was a raining period, and which favored their growth. As indicated in other studies, environmental factors, especially dampness enhance microbial growth and multiplication [24]. The findings of this study show the need for increased monitoring of indoor air quality in workplaces, this is because according to Katiyar [25], the organisms isolated are dangerous as pathogenic living cells or cause sensitivities as a result of prolonged exposure.

From the study the mean total coliform counts also which exceeds the recommended limit of 10^3cfu/m^3 suggested by National Institute of Occupational Safety and Health (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH) (500 cfu/m^3) [22] and Residential Limit Values (RLV) of 250 cfu/m^3 for bacterial concentrations [15]. In another studies, [26], however reported 0 to 18 cfu/m^3 while [27] reported between 10 and 170 cfu/m^3. Again, Sule, et al. [27] stated that ventilation, health status, human traffic and activities are some of the factors which could increase the level of microorganisms in the indoor air. The variation of bacterial load in indoor environments could also be due to environmental factors such as ventilation system of rooms, temperature, humidity, and particulate matter concentration [28].

Mycoflora air quality assessment is one of the most vital investigations of airborne fungal, both to estimate the health hazard and to create standards for air quality control [29]. The findings of this study also revealed that the mean total heterotrophic fungal counts for the morning session ranges from 1.24 x 10^4cfu/m^3 (DSA Office) to 3.91 x 10^4cfu/m^4 (CSO Office) while the mean total heterotrophic fungal counts for the afternoon session ranged from 8.87 x 10^3cfu/m^3 (CSO office) to 5.13 x 10^4cfu/m^3 (Lecturer Office 2). The counts obtained were higher compared to those reported by Mirhoseini, et al. [30], ranging between 203 and 216 cfu/m^3 for offices in their study. Other studies have shown fungal concentrations ranging between 103 and 1116 cfu/m^3 in offices [31,32]. The fungal counts obtained from the study also exceed the recommended limit of 10^3cfu/m^3 proposed for fungal concentrations in the air [15]. Again, the work conducted by a World Health Organization expert group on assessment of health risks of biological agents in indoor environments has set the guideline of bioaerosol counts at 500 cfu/m^3, if higher than this, the environment is considered as contaminated [33]. According to the values obtained in this study, it is rated to be either highly or very highly polluted as the values obtained clearly exceeds the permissive standard of 500 cfu/m^3 for indoor environments. The number of staff per office in relation to the office area, ambient temperature, relative humidity, poor ventilation, indoor traffic, together with poor sanitary measures as at the time of this study might be responsible for the level of bioaerosol recorded in this study. This is in agreement with [34]. Furthermore, it is likely that the dampness situation in Lecturer office 2 sampled might have also created conducive condition for both bacteria and fungi, which is in agreement with [35], who also stressed that this can be dispersed through droplets during disturbing and then maintained in aerosol suspension. Mouli, et al. [36] have also stated that specific environmental conditions such as temperature and relative humidity are required to to grow and propagate with their concentration significantly affected. This is important because the study was carried out during the rainy season. The fungal isolated obtained throughout the study might contain some fungal which are known allergies, while others could be opportunist in nature [37]. Fungal spores has been considered to be correlated with air pollution, also they had been proposed to be a cause of adverse health effects on humans, animals and plants [38]. Also, these extremely tiny fungal spores cause allergic reactions in susceptible people and respiratory irritation in non-allergic people. As a result, inhalation of fungal spores by highly susceptible people can have fatal consequences.

5. CONCLUSION

The Bioaerosol assessment of selected offices within Captain Elechi Amadi Polytechnic, Rumuola was investigated during the study period and the total heterotrophic bacterial counts and total coliform counts within most of the offices were high exceeding the recommended limit of 10^3cfu/m^3 suggested by National Institute of Occupational Safety and Health (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH) (500 cfu/m^3) and Residential Limit Values (RLV) of 250 cfu/m^3 for bacterial concentrations. The fungal counts also exceeded the recommended limit of 10^3cfu/m^3 and world health organisation expert guildeline of 500 cfu/m^3. Consequently, there is a need for health education, good sanitary practices and controlling factors that

increase the presence of bioaerosols (bacteria and fungi) in air within the offices, as it can result in health challenges of the staff and students thereby reducing productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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