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Microbiological assessment of air quality of selected locations within Veritas University, Abuja, Nigeria

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Abstract

The study investigated the microbiological quality of indoor and outdoor air of certain locations - the chapel, basement, classroom, hostel, as well as the old and new microbiology laboratories in Veritas University, Abuja. The settle plate technique using open Petri dishes containing different culture media was employed to collect samples daily for 5 weeks at 7 days intervals. Standard microbiological methods were employed for the identification of bacterial and fungal isolates. The bacterial counts ranged from $1.90x10^6$ to $5.3x10^6$ and 2.90×10^6 to 6.20×10^6 for indoor and outdoor air while the fungal counts ranged from 2.30×10^6 to 3.70×10^6 and 2.10×10^6 to 4.40×10^6 also for indoor and outdoor air respectively. The bacterial isolates were identified to include *Bacillus* species and *Staphylococcus aureus* with percentage occurrence of 44.0% and 56.0% respectively. The results obtained also showed the occurrence of three major fungal species namely *Aspergillus* sp (60.0%), *Rhodotolura* sp (5.0%), and *Rhizopus* sp (35.00%). The bacterial isolate, *Staphylococcus aureus* (56.0%) was shown to be the most predominant airborne bacteria while *Aspergillus* sp (60.0%) was the most frequently isolated fungal species. The 95% confidence level statistical analysis showed a significant difference between the indoor and outdoor air microbial load of the selected locations. Data generated underline the usefulness of monitoring the air quality of the selected locations because the contamination of indoor and outdoor habitats can cause health problems and even an increase in human mortality.

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Introduction

People inhale a lot of microorganisms in the form of bioaerosols (Kalwasinska *et al.*, 2012). Bioaerosols are colloidal suspensions in the air that include or have viruses, fungal spores and conidia, bacterial endospores, plant pollen, and fragments of plant tissues attached to them. (Kalwasinska *et al.*, 2012). They are airborne particles that are living or originated from living organisms. They are ubiquitous, extremely complex, and can be either natural or man-made. Biological aerosol particles (cells, cell fractions, or organic matter of animal, plant, and microbial origin) make up a large number of atmospheric aerosols, accounting for up to 50% of all aerosol particles (Usmana, 2018). The content and size of bioaerosol can range from 20 nm to >100 m, depending on the source, aerosolization mechanisms, and local ambient circumstances (Usmana, 2018). Because we breathe 10 m^3 of air every day and spend 80–95 percent of our lives indoors and 95–98 percent of our lives outdoors, it has been proven that indoor and outdoor air quality is one of the most critical elements influencing our overall life quality (Cabral, 2010). Microorganisms are thought to be the most complex and least studied of the major forms of outdoor air pollutants. The air flora of any location is made up of a wide array of microorganisms that spread from their source for a variety of reasons. Airborne particulate matter incidence patterns change from place to place and season to season.

Though there are significantly fewer atmospheric microorganisms than there are in oceans and in soil, there is still a large enough number that they can affect the atmosphere (Amato, 2012). Once suspended in the air column, these microbes have the opportunity to travel long distances with the help of wind and precipitation, increasing the occurrence of widespread disease. Typically, microbes will be suspended in clouds, where they are able to perform processes that alter the chemical composition of the cloud and may even induce precipitation (Amato, 2012).

Indoor and outdoor environments contain a complex mixture of live and dead microbes, fragments, toxins, allergens, volatile microbial organic compounds, and other chemicals (Adeleye *et al.*, 2018). Their pollution can cause health problems and even an increase in human mortality (Adeleye *et al.*, 2018). There is growing evidence that exposure to biological agents in the indoor and outdoor environment can have adverse health effects. The view made by the World Health Organization (WHO) on the number of epidemiological studies showed that there is sufficient evidence for an association between indoor and outdoor dampness-related factors and a wide range of effects on respiratory health, including asthma development, asthma exacerbation, current asthma, respiratory infections, upper respiratory tract symptoms, cough, sneeze and dyspnea (WHO, 2010; McMahon, 2012).

Recent research has revealed an increase in the number of allergic reactions to microbial spores, with young individuals accounting for the majority of allergy sufferers (Ewa *et al.*, 2018; Andualem *et al.*, 2019; Emuren and Ordinioha, 2016). As a result, air quality must be assessed regularly to determine how it affects the health of individuals going about their daily lives. In Nigeria, there are works on monitoring airborne microorganisms in indoor and outdoor environments with an emphasis on hospital environments. Thus, the focus of this research is to assess the air quality of the chapel, classroom, basement, hostel, and microbiological laboratories at Veritas University, where students and staff spend a significant amount of their time.

Material and methods

Study area

Veritas University is a private university, located in Abuja. It was founded in March 2002 by the Catholic Bishops Council of Nigeria. The Microbiological Laboratories serve for practical purposes; carrying out experiments, the classrooms serve as lecture rooms, the chapel serves for worship purposes, the basement serves also as lecture rooms, and the hostel is for the accommodation of the students. On average, over 100 students and staff visit and stay in these areas daily, making them the busiest areas in the institution.

Sample collection

Air sample was collected for a period of 5 weeks at 7 days interval using the settle plate technique also known as the sedimentation method (Usmana, 2018). The sampling was carried out once a day for five weeks; each day, before the students and staff come into the selected areas. The Petri dishes containing nutrient agar and Potato dextrose agar (for bacterial and fungal species respectively) in triplicates were exposed at strategic locations at a height of 1 to 1.5 m above the ground to avoid contamination from floor microbes both indoors and outdoors for the duration of 20 minutes after which the lids were replaced and incubated at 37°C for 24 hours for bacterial media and at room temperature for five days for the fungal medium (Usmana, 2018).

Enumeration of isolates

The Petri plates exposed at the various sampling points were incubated at 37° C and 28° C for bacteria and fungi plates respectively for 24 hours. Then, the plates were examined for distinct colonies and counted. The counts were expressed as colony-forming units per ml (CFU/ml).

Identification of the isolates

Distinct colonies were sub-cultured on freshly prepared nutrient agar medium and then streaked successively to obtain pure cultures for bacteria. Pure cultures of bacteria were then characterized and identified based on colonial characteristics, microscopy, biochemical tests, and sugar fermentation tests as described by Okereke and Kanu (2020) while the fungi isolates were identified by suspending part of the culture from the petri dish in one drop of cotton blue on a clean glass slide and examined microscopically.

Statistical analysis

The data collected were subjected to correlation matrix analysis to establish relationships between the microbial groups. A two-way factor ANOVA test at a 95% confidence interval was employed for the comparison of the bioaerosol data sets of the outdoor and indoor air. The mean and variance were used to characterize the normally distributed data.

Result and discussion

Result

From the results obtained, the average bacterial counts ranged from 1.90 x 10^6 to 5.3 x 10^6 and 2.90 x 10^6 to 6.20 x 10^6 for indoor and outdoor air while fungal counts ranged from 2.30 x 10^6 to 3.70 x 10^6 and 2.10 x 10^6 to 4.40 x 10^6 also for indoor and outdoor air respectively. The bacterial count for each location - old lab, new lab, chapel, basement, hostel and classroom were 4.90 x 10^6, 5.3 x 10^6, 4.8 x 10^6, 2.30 x 10^6, 2.50 x 10^6 and 1.90 x 10^6 for indoor air and 6.20 x 10^6, 5.80 x 10^6, 4.90 x 10^6, 3.30 x 10^6, 2.90 x 10^6 and 3.10 x 10^6 for outdoor air respectively while that of fungi for same locations were 3.20 x 10^6, 3.10 x 10^6, 3.70 x 10^6, 2.30 x10^6, 2.90 x 10^6 and 2.70 x 10^6 for indoor air and 4.31 x 10^6, 3.70 x 10^6, 4.40 x10^6, 3.30 x 10^6, 3.30 x 10^6 and 2.10 x 10^6 (Table 1).

Table 1. Microbial counts of Indoor and Outdoor air in the study locations.

Bacteria	Location					
	Old Lab	New Lab	Chapel	Basement	Hostel	Classroom
Indoor	4.90 x10^6	5.3 x10^6	4.8 x10^6	2.30 x 10^6	2.50 x 10^6	1.90 x 10^6
Outdoor	6.20 x 10^6	5.80 x 10^6	4.90x10^6	3.30 x 10^6	2.90 x 10^6	3.10 x 10^6
Fungi						
Indoor	3.20 x 10^6	3.10 x 10^6	3.70x 10^6	2.30 x 10^6	2.90 x 10^6	2.70 x 10^6
Outdoor	4.31x10^6	3.70 x 10^6	4.40 x 10^6	3.30 x 10^6	3.30 x 10^6	2.10 x 10^6

The result of the findings also revealed the presence of three major fungal species (Table 2): *Aspergillus flavus* (60%), *Rhodotolura* species (5%), and *Rhizopus* species (5%). (35%) while *Bacillus* species and *Staphylococcus aureus* were the two bacterial species isolated with percentage occurrences of 56% and 44% respectively. It was also observed that the old laboratory contained 100% *Bacillus* species and 0% *Staphylococcus aureus*, whereas the new lab showed 60% *Bacillus* and 40% *Staphylococcus aureus*. *Bacillus* species and *Staphylococcus aureus* were also isolated from the Chapel (25%, 75%) Basement (50%,

50%), Hostel (50%, 50%), and Classroom (60%, 40%) respectively (Table 3). *Bacillus* species was the most frequently isolated bacterial species (56%) in this study while *Aspergillus flavus* was the most frequently isolated fungi (60%) respectively.

Table 2. Percentage occurrence of microbial isolates in the air.

Microbe	Fungi	Frequency	Percentage
Fungi	*Aspergillus flavus*	12	60%
	Rhodotolura spp	1	5%
	Rhizopus spp	7	35%
Bacteria	*Bacillus* spp	14	56%
	Staphylococcus aureus	11	44%

Table 3. Distribution of bacteria in the air at different locations.

Location	Bacteria	
	Bacillus spp	*Staphylococcus aureus*
Old Lab	100%	0%
New Lab	60%	40%
Chapel	25%	75%
Basement	50%)	50%
Hostel	50%	50%
Classroom	60%	40%

The distribution of fungi in the air at different locations, (Table 4) shows *Aspergillus* sp accounted for 75% of the fungi contaminants in the old lab, 0% for *Rhodotolura* species, and 25% for *Rhizopus* species. The result of the distribution of bacteria species in indoor and outdoor air (Table 5) revealed that *Bacillus* sp accounted for 46.5% of the bacteria found in indoor air, while *Staphylococcus aureus* accounted for 53% also, *Bacillus* species made up 70% and *Staphylococcus aureus* 30% of the bacteria found in outdoor air.

Table 4. Distribution of fungi in the air at different locations.

Location	*Aspergillus flavus*	Fungi	
		Rhodotolura spp	*Rhizopus spp*
Old Lab	75%	0%	25%
New Lab	100%	0%	0%
Chapel	100%	0%	0%
Basement	50%	50%	0%
Hostel	60%	0%	40%
Classroom	0%	0%	100%

Again, for fungal distribution in indoor and outdoor air (Table 6), *Aspergillus* species accounted for 63.6% of the fungi isolated from indoor air while *Rhodotolura* species and *Rhizopus* species occurrences were 0% and 36% respectively. For outdoor air, *Aspergillus* species accounted for 55.6%, *Rhodotolura* species 11%, and *Rhizopus* species 33%.

Table 5. Distribution of bacteria in the indoor and outdoor air.

Type of Air	Bacteria	
	Bacillus spp	*Staphylococcus aureus*
Indoor	46.5%	53%
Outdoor	70%	30%

Table 6. Distribution of fungi in the indoor and outdoor air.

Type of air	*Aspergillus flavus*	Fungi	
		Rhodotolura spp	*Rhizopus* spp
Indoor	63.6%	0%	36%
Outdoor	55.6%	11%	33%

Discussion

The health of an individual in a particular environment is determined greatly by the quality of air the individual breathes. Therefore, there is a need for the assessment of the air quality of any location from time to time, especially where individuals spend most of their day. The present study investigated the indoor and outdoor air quality of selected locations within Veritas University, Abuja, Nigeria.

The microbial load of the studied locations ranged from 1.90x 10^6 to 6.20 x 10^6 which is higher than those reported by Agwaranze *et al.* (2018), who found that the highest and lowest bacterial counts for indoor and outdoor air were 1.52 x 10^5; 1.5 x 10^4 and 5.2 x 10^4; 1.2 x 10^4 respectively. The bacterial counts were also higher than those reported by Andualem *et al.* (2019). The air near the University's old laboratory had the highest bacterial count (6.20 x 10^6), which is characterized by structures that need to be restructured, whereas the Basement had the lowest bacterial count (2.30 x 10^6). The availability of potent attachment surfaces in old structures, as opposed to new ones, which are normally covered with protective finishing that prevents microbial attachments to a large extent, could be one reason for the higher counts observed in the air around old laboratories.

The result of the findings revealed three major species of fungi, namely; *Aspergillus flavus, Rhodotolura* sp, and *Rhizopus* sp while the bacterial species included; *Bacillus* sp and *Staphylococcus aureus*. Similar observations and isolates have been reported by Ekhaise and Ogboghodo (2011), who isolated *Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli*, *Bacillus cereus, Serratia marcescens,* and *Micrococcus* species, in their study on airborne microflora in the atmosphere of a hospital environment of the University of Benin Teaching Hospital (UBTH), Benin City, Nigeria.

It was also observed that *Bacillus* spp and *Staphylococcus aureus* were abundant and kept reoccurring during the study. This result concurs with the reports of Agwaranze *et al.* (2018) and Ewa *et al.* (2018), who found those species to be among the most dominant bacteria in their study in South-Southern Nigeria. The study revealed *Aspergillus flavus* to be the most occurring fungi and this agrees with the reports of (Jaffal *et al.* (1997); Ekhaise *et al.*, 2010; Ekhaise and Ogboghodo (2011); Agwaranze *et al.*, 2020). *Aspergillus* species *is* recognized for its harmful carcinogenic consequences. Its presence in the air consequently is a pointer to the harm it poses to the health and livelihood of students, lecturers, and the workforce population of the study location.

The study also showed outdoor air to be more contaminated than interior air, which is in agreement with the works of (Agwaranze *et al.*, 2020; Andualem *et al.,* 2019; Emuren and Ordnioha, 2016). The unpredictable nature of air in the external environment, which typically comes from many sources, could be one explanation for greater pollutants in outdoor air. The appearance of various bacterial and fungal contaminants also points to the availability of sources of contamination such as waste bins, garbage, sewage, etc. in the environment as well as the unsanitary circumstances of individuals in the research location.

Statistical analysis using ANOVA showed that there was no significant relationship between fungal and bacterial contamination and the nature of air (indoor or outdoor) ($P > 0.05$). Chi-square analysis however showed that there was a significant relationship between the location of air and the occurrence of fungal contaminants ($P < 0.05$). This implies that the degree to which fungal contamination occurs is dependent on the location. An association between location and occurrence of bacterial contaminants was however not established ($P > 0.05$).

Conclusion

The atmosphere is complex and embodies a lot of microbes, both those that are beneficial and those that are harmful to humans and animals. The research work showed the study location to consist of various microbes of significant public health importance. The most common bacteria isolated from this study is *Staphylococcus aureus* which is capable of causing serious health issues to the students that spend most of their time within the study locations and the general public if the cumulative effect is not well managed. *Aspergillus flavus* which was the most dominant fungi identified in this study is also a pointer to the harm, the students and workers in the study location stand to face if effective management strategies are not put in place.

Recommendations

Based on the findings, it is recommended that the regulatory and enforcement agency develop more robust monitoring mechanisms, regulations, and enforcement. Also, there is need for a national drive on clean energy to form cleaner air initiatives for a safe environment as well as reduce particulate matter in the city. Location plays a vital role in determining the rate of microbial contamination. As such, surfaces that have the potential of serving as attachment grounds for microbial contaminants should be properly managed so as to prevent a rise in the rate of contamination and degree of harm to people in general.

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